UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
PSYCHOLOGY

Vol. 2, No. 1, pp. 1-156 March 16, 1916

VARIATIONS IN EFFICIENCY DURING THE DAY, TOGETHER WITH PRACTISE EFFECTS, SEX DIFFERENCES, AND CORRELATIONS

BY

ARTHUR I. GATES

UNIVERSITY OF CALIFORNIA PRESS
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PHILOSOPHY.—George H. Howison Editor. Price per volume $2.00.

Cited as Univ. Calif. Publ. Philos.

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FOREWORD

The investigation presented in this article was carried on during the college year 1913-1914, being a part of the regular academic work of the writer.

It is a privilege to express my obligations to the many who have materially aided in the work: to Professor C. E. Rugh for assistance in making arrangements with the school officials for carrying on the work; to Mr. Morris C. James, superintendent of the Berkeley schools, for permission to take up the work among the schools of this city; to the principals of the three schools visited, for permission to use their pupils as subjects in the experimentation, as well as for their kind assistance in furnishing private rooms in which the tests might be conducted; and to the several teachers whose schoolrooms I invaded and whose regular work I seriously disturbed. Greatest of all is my indebtedness to my teachers Professor G. M. Stratton and Professor Warner Brown who introduced me to

the methods of experimental psychology and from whom I have enjoyed almost daily advice, assistance, and encouragement from the time of the selection of the problem to the publication of the results.

Introduction

Sundry studies have appeared whose results seem to bear evidence of the existence of a variation in efficiency during the day, for various mental and physical activities. In 1906 an effort was made by Howard D. Marsh[1] to collect and review the scattered evidence produced before that time, together with the results of experimental investigations conducted by himself. Even under the stimulus given by his efforts, the work has gone on but slowly. Extensive researches by hosts of investigators have been undertaken on the cognate subject of mental fatigue and kindred educational and psychological problems, but the equally important consideration, that of mental adaptation has, until in very recent times been quite neglected. Many current text-books of pedagogy and psychology scarcely give the matter passing notice, indicating that the answer to such a question is as yet in such an unsettled condition that even a tentative statement with regard to it would be unsafe.

Yet there is much reason to believe that the exact demonstration of such diurnal variations in efficiency is a matter of perhaps greater import than the solution of many other problems of like nature to which more attention has been given. A casual consideration will show that this phenomenon is one intimately connected with that of fatigue. Pure fatigue sets the limit to the amount of work that can be done at any time, and feelings of fatigue and kindred factors likewise tend toward the decrease in quality and quantity of accom-

1 "The Diurnal Course of Efficiency", *Archives of Philosophy, Psychology and Scientific Methods*, no. 7 (July, 1906).

plishment. It is very probable that the diurnal course of efficiency, independent of whether we work or rest, at times runs parallel with and at times directly opposite to the course of fatigue and other factors which tend to diminish the capacity of the organism for work. It is, therefore, not impossible that many of the discordant and often surprising results produced by investigators of fatigue and kindred problems are largely due to the failure to take account of the ebb and flow of efficiency during the day. Not a few investigators, for instance, have found that instead of an inferior quantity and quality of work resulting, as one would expect, after several hours of continued activity, the very opposite is the case. Such surprising results might be accounted for in part, if the truth were known, by the fact that at the beginning of the period the tests were made in the valley, and at the end of the period on the crest of the daily wave of efficiency, and that the difference in this respect more than counteracted the opposing effects of fatigue.

If conditions similar to the hypothetical one just mentioned, do exist in reality, clearly it is necessary to determine and take account of them before fatigue can be adequately determined.

It should be stated at once, however, that fatigue is one of the factors so intimately bound up with the rhythm of efficiency that entirely to separate and measure either of them seems only theoretically possible. Nevertheless, it does not seem impossible that the separation may be in part accomplished. In the present investigation, it has been found necessary to take as subjects groups of pupils from the grammar grades, engaged in their regular school work. The effects of *pure* fatigue resulting from their varied activities have not been eliminated, but the effects of feelings of fatigue, loss of interest, boredom, and the like, which are thought by many investigators to be the more important causes of loss of efficiency during the day, have been largely, if not entirely, avoided, as will be explained later.

If experiments show that diurnal rhythms of efficiency for different mental functions exist, practical suggestions with regard to the arrangement of the school program should follow. In a great many schools at the present time, the distribution of the subjects throughout the day is to a large extent arbitrary, and in cases where the schedules are made out according to fixed opinions of one sort or another it is possible that they may not be well grounded, psychologically. In several of the schools which have been visited during this work, arithmetic was given early in the morning chiefly for the reason that since it was found to be work of a difficult and severe sort, it should be given when the pupils were fresh. Winch has shown that the same opinion is current in English schools, although his investigations indicate that a later hour of the forenoon was considerably more favorable for arithmetical work.[2] Further investigation on the diurnal course of efficiency for the several school functions would greatly aid in establishing the program on a sound basis.

The results of previous research on the daily ebb and flow of efficiency have been varied and conflicting. We could hardly expect the case to be otherwise. In the first place, much of the evidence bearing on this phenomenon has appeared in experimental work directed primarily to other ends, and with many important modifying factors left out of account. Moreover, the experiments have been conducted with subjects of all ages, both children and adults; with students, professional men, and laborers; in winter and in summer, in hot and cold climates and on hot and cold days. Peoples whose habits of life and whose interests differ have been subjected to all kinds of mental and physical tests, some adequate and some not, by different men using many different methods. Under such conditions there is no reason to be surprised that the results are not in entire accord with one another.

[2] Winch, W. H., "Mental Adaptation During the School Day, as Measured by Arithmetical Reasoning", *Journal of Educational Psychology*, vol. 4, 1913, pp. 17-28, 71-84.

In general it was thought advisable not to attempt to solve the problem by scanty data collected from a large number of different school grades, or from children of widely different age and working with different subjects, but rather to collect a larger amount of evidence from subjects of nearly the same age and doing essentially the same work. With the latter method, the results would not only be more reliable, but in case differences in the course of efficiency are found between the several groups, the factors which conspired to produce those differences would be more clearly indicated. Although subsequent investigation of each of the several factors would be required to produce entirely reliable conclusions, yet we could at least say, from the facts gained by this work, that the variations from group to group were not due to differences in age or mental development, or to differences in the chief form of work or interest of the subjects tested. There might, indeed, be some indication that the variations were due to differences in home or school environment, to methods of teaching or to other factors which were beyond the control of the experimenter. If, on the other hand, the course of efficiency should be found the same for all the groups it would be evident that such a rhythm is one that persists in spite of such differences between the several groups tested.

II

Chief Causal Factors in the Diurnal Course of Efficiency

1. *The Night-Day Rhythm of Sleep and Activity.*

It has been contended that one of the chief causal factors in the determination of the diurnal curve of efficiency is to be found in the rhythm of sleep. The curve of sleep is, of course, at its greatest depth during the night, in the stage of real sleep in the ordinary sense of the word; the maximum occurring from one to three hours after the beginning, and gradually decreasing in intensity until awakening. A similar

state, it is alleged, although qualitatively and quantitatively differing in certain respects, occurs in the day, being felt at one extreme as a sort of inertness and sluggishness which disappears as the organism approaches the condition of complete wakefulness or consciousness. Such a condition of sluggishness is doubtless within the experience of everyone, being greatest immediately after waking, and continuing through the morning hours for varying lengths of time. Such a stage we generally call "warming up," and in the earlier part of its course we make use of such expressions as "We haven't got into the swing yet," "Wait until we settle down to business," etc.[3] Later on when we have arrived at the maximum of wakefulness, consciousness, or fitness for work, we are generally aware of a greater efficiency. The work seems more absorbing, mind and muscle work with smoothness, effectiveness and dispatch. The work is then in a condition of "full swing"[4]; we are at our best.

The curve below, plotted by Michelson, will show the form such a night-day rhythm of sleep might take.[5]

Normal ability is designated by the base line in the figure. It will be noticed that the condition of inertness gradually decreases, but that the stage of normal consciousness is not reached until the late forenoon, with the maximum occuring late in the afternoon.

At this point one begins to wonder what are the facts that lie deeper; what are the factors which account for the characteristics of the curve of sleep. The answer to this question must lie in the explanation of sleep itself. When one seeks

[3] For a discussion of these, see Max Offner, *Mental Fatigue* (Trans. by Whipple, 1911), pp. 63-73.

[4] Kraeplin and his school call this condition "fitness for work" (Arbeitsbereitschaft). For extensive work on the various phases of the work-curve see E. Kraepelin, "Die Arbeitskurve", *Philosophische Studien*, vol. 19 (1902), pp. 459-507; also the various articles in *Psychologische Arbeiten*, especially "Ueber Ermüdung und Erholung", by W. Rivers and E. Kraepelin, Bd. I, pp. 627-678.

[5] M. Michelson, "Ueber die Tiefe des Schlafes", *Psychologische Arbeiten*, vol. 2, pp. 84-117. See also Marsh, "The Diurnal Course of Efficiency" (1906), p. 73.

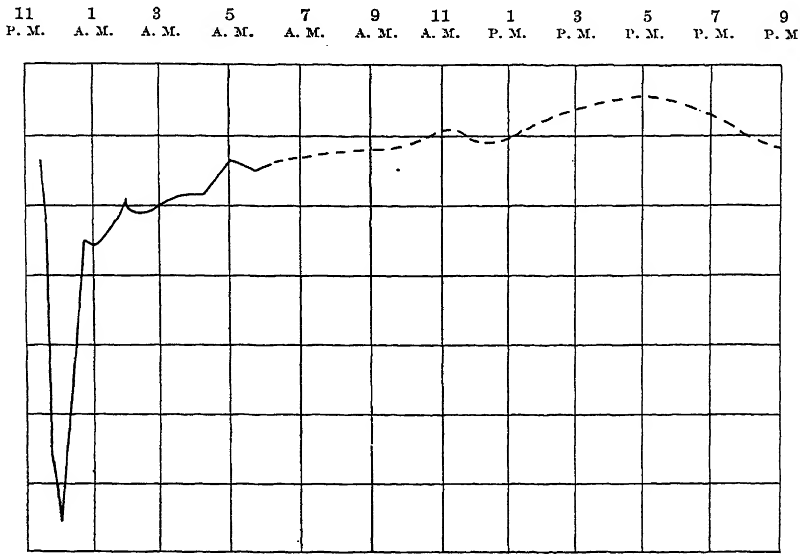

Fig. 1. Showing the hourly depth of sleep. (Marsh, after Michelson.)

for information on this point, he is immediately confronted with a host of theories.[6] From the many hypotheses which have been advanced, the following may be taken as representative:

(1) *The Accumulation-of-Acid-Waste-Products Theory* advocated by Preyer[7] and Obersteiner.[8] According to this view, the activities of the day result in continued accumulation of acid wastes products which bring on loss of irritability and fatigue, finally resulting in sleep.

(2) *The Consumption-of-Intramolecular-Oxygen Theory* advanced by Pflüger.[9] Here it is alleged that the brain-cells during the waking hours use up their store of oxygen faster

[6] For an excellent summary and discussion of the numerous theories of sleep see Piéron, *Le problème physiologique du sommeil*, Paris, 1913. For shorter descriptions in English see W. H. Howell, *A Text-Book of Physiology* (Ed. 5, 1913), chap. 13. Also B. Sidis, *An Experimental Study of Sleep* (1909), p. 106.

[7] Preyer, *Centralblatt f. d. Med. Wiss.*, vol. 13 (1875).

[8] Obersteiner, *Allgemeine Zeitschrift f. Psychiatrie*, vol. 29 (1873), p. 224.

[9] Pflüger, *Archive f. d. gesammte Physiologie*, vol. 10 (1875), p. 468.

than it is replenished, causing loss of irritability; so that when external stimuli are withheld, oxydization in the cells sinks below the level necessary to arouse consciousness.

(3) *The Toxin Theory* of Piéron.[10] According to this theory the catabolic processes of the system, especially in the brain, form a special toxin which finally accumulates in sufficient quantity to inhibit the action of the cortical cells.

(4) *The Neuron Theory* of Ramon y Cajal[11] and Duval.[12] It is assumed by these investigators that the arborizations of the afferent fibres and the dentrites of the cells, according to one form of the neuron theory of the structure of the nervous system, communicate by contact only, and that the dentrites are contractile. Sleep is brought on by their mechanical retraction due to continued activity.

(5) *Psychological, Biological, and Combination Theories.* A. The *Psychological Theory advanced* by Heubel holds that mental activity depends upon incoming sensory stimulations, particularly those from the periphery; and where such stimulations are absent, sleep results.[13] B. According to the *Biological Theory* theory of Claperède, sleep is to be considered, not as a passive state, resulting from chemical actions of whatever sort, but as an active, positive function of an instinctive and protective nature.[14] C. The theory recently advanced by Sidis is in a large measure a combination of the last two, with certain modifications. To put it in his own words: "Biologically regarded, sleep is as much an instinct as hunger or thirst. . . . Physiologically and psychologically regarded, sleep is an actively induced passive state in relation to the external environment; the psycho-physiological systems have their thresholds raised in relation to external stimulations; the rise of

10 Piéron, *op. cit.*

11 Ramon y Cajal, *Archive für Anatomie u. Physiologie* (1895), p. 375.

12 Duval, *Comptes rendus de la soc. de biol.*, vol. 2 (1895), p. 86.

13 Heubel, "Abhängigkeit des wachen Gehirnzustandes von aüsseren Erregungen", *Pflüger's Arch.*, vol. 14 (1877), p. 158.

14 Claperède, "Esquisse d'une theorie biologique du sommeil", *Arch. de Psychologie*, vol. 4 (1904), pp. 245-249.

threshold is induced by a mass of impressions possessing little or no variability, by limitation or by relative withdrawal of stimulations, or what is the same, by monotony of stimulations and by limitation of voluntary movements.''[15]

(6) *The Anemia Theory* of Howell.[16] This theory is based on observations showing variations in the flow of blood through the brain in sleep and wakefulness.

Most of the hypotheses just mentioned have for their support a greater or less amount of experimental evidence. Such being the case, it seems most reasonable to suppose that sleep is produced, not by any one of the various factors singled out by the different investigators, but by the combined influence of a number of factors working together.

The purpose of this excursion into the uncertain realm of theory has been to select some hypothesis which, for the sake of illustration, might be applied to the night-day curve of sleep given above (Figure 1). The opinions of Claperède and Sidis that sleep is an actively induced, normally recurring condition, and the opinion of the same writers and also of Heubel, that the effects of the varied sensory experiences are causal factors in the induction of sleep, seem reasonable. Keeping this in mind, the *Anemia Theory* of Howell might be described in more detail for the purpose of applying it to the night-day rhythm, not without admitting, however, the possibility that accumulation of acid waste products and toxins and perhaps other factors have also some causal effect.

The *Anemia Theory* of Howell is based on fairly substantial evidence of an anemic condition of the brain during sleep, and assumes that this condition is largely occasioned by a rhythmic loss of tone in the vasomotor center in the medulla in consequence of fatigue from the continued activities of the day. The normal activity of this center, due to the constant flow of sensory stimulation and the activity of the brain, is needed

15 *Op. cit.*, p. 98.

16 Howell, W. H., *Journal of Experimental Medicine*, vol. 2 (1897), p. 313.

to cause constriction of the blood-vessels of the body, especially of the skin, on which depends the flow of blood to the brain. This continued activity fatigues and lowers the irritability of the vasomotor center, stronger and stronger stimulation being necessary to maintain its normal tone; eventually its effect on the blood-pressure becomes insufficient to maintain an adequate flow through the brain, and unconsciousness or sleep results.

Adapting this theory to the curve of sleep shown in Figure 1, it would seem that although the return to consciousness is sudden, the complete readjustment of the anemic condition takes place more slowly, since it is dependent on the cumulative effects of sensory experience and the increasing activity of the brain.

At this point suggestive indications might be brough forth by a comparison of the night-day rhythm of sleep with the diurnal course of the vital activities. Since the activity of the brain and of the vasomotor center, and, consequently, the rhythm of sleep, is dependent in part on the constant flow of sensory impulses and on the nervous discharges, the course of the vital activities may be in part a cause as well as an effect of the night-day rhythm of sleep.

The experimental evidence bearing upon the diurnal changes in circulation is not extensive, but it points rather consistently in one direction. The work of Vierordt,[17] Binet,[18] Storey,[19] Erlanger and Hooker,[20] and Marsh[21] agrees fairly well in showing a curve of the pulse-rate with a minimum in the morning and increasing somewhat irregularly to a maximum in the late afternoon.

The pulse-rate is so delicately susceptible to changes due to muscular and mental activities, digestion of food, etc., that

[17] Vierordt, K., *Daten und Tabellen* (1888), pp. 95-150.

[18] Binet, A., "Les changements de forme du pouls capillaire aux differentes heures", *Année Psych.*, vol. 3 (1897), pp. 10-29.

[19] Storey, T. A., "Some Daily Variations in Height, Weight and Strength", *Am. Phys. Ed. Rev.*, vol. 6 (1901).

[20] Erlanger and Hooker, "An Experimental Study of Blood-pressure and Pulse-pressure in Man", *Johns Hopkins Hosp. Reps.*, vol. 12 (1903), pp. 145-373.

[21] Marsh, "The Diurnal Course of Efficiency", pp. 4-9.

reliable curves can be obtained only with the greatest difficulty. Considering the scarcity of experimental evidence and the difficulty of the problem, the indications above, of a morning minimum and an afternoon maximum in pulse-rate, are not altogether reliable.

The diurnal curves of respiration and temperature seem to be very closely related to each other and to the curve of pulse-rate. Vierordt,[22] Binet, [23] Tigerstedt,[24] Johannson[25] and Marsh[26] agree fairly well in their determinations of the former two curves. Both respiration and temperature seem to be least from 5 to 6 A. M. increasing gradually to a maximum at about 5 or 6 P. M. Similar experiments on the monkey and various birds by Galbraith and Simpson have shown similar daily rhythms in temperature.[27] It appears then, that in a general way,—neglecting the important factors of meals, rests, and the like,—pulse, respiration, and temperature vary alike from an early morning minimum to a late afternoon maximum.

It must be observed, however, that all the rhythms just mentioned are subject to fluctuations of greater or less extent under the influence of many different factors. For instance, the curve of sleep, plotted above, shows a decided drop following the mid-day meal. Howell, in adapting his theory to this situation, says: "The drowsiness that follows a heavy meal is probably due mainly to the mechanical effect of a dilation of the blood-vessels of the viscera and the consequent diminution in the blood-flow through the brain."[28]

The increasing sleepiness in the evening (see Figure 1) is probably due in part to effects of the evening meal as well as

[22] *Op. cit.*

[23] *Op. cit.*

[24] Tigerstedt, *Lehrbuch der Physiologie* (1902).

[25] Johannson, "Ueber die Tagesschwankungen des Stoffwechsels und der Körpertemperatur", *Skand. Archive für Physiol.*, vol. 8 (1898), p. 85.

[26] *Op. cit.*

[27] Galbraith and Simpson, "Conditions Influencing the Diurnal Wave in Temperature of the Monkey", *Journal of Physiol.*, vol. 30 (1903), p. 20; "Temperature Variations in Nocturnal and Other Birds" *ibid.*

[28] *Text-Book of Physiology*, p. 263.

to the changes brought about by the fatiguing effects of the continual sensory stimulation and of the general mental and physical activity during the day.

Age and sex are factors which may influence the night-day course of sleep and activity. Habits of work and rest, the time of meals, time of rising, external conditions, and many other factors undoubtedly have their effect.

2. *Fatigue and Feelings of Fatigue.*

The intimate relation of the problem of fatigue to that of the diurnal course of efficiency has been mentioned before. The curve of fatigue runs opposite to that of adaptation and, as we have just seen, to the curves traced by the night-day rhythm of sleep and the vital activities.

The extensive investigations which have been conducted for the past half century, primarily for the purpose of determining the causes, nature and extent of fatigue, have naturally thrown some light upon the problem of the diurnal course of efficiency. On the one hand, fatigue from continuous work tends to limit the amount and quality of work that can be accomplished in any given time, and is, on that account, a determining factor in the course of efficiency. On the other hand, the existence of an independent variation of efficiency through the day presents a difficulty in determining the amount of fatigue resulting from continued activity; and is a factor which must be taken into account if quantitative or qualitative measurements of fatigue are to be obtained.

The investigation of fatigue has shown that, unfortunately, this is by no means the only obstacle to be avoided. The effects of practise, habituation, swing or fitness for work, spurts, age, sex, and other factors, furnish influences which must be taken into account separately before fatigue in unadulterated form can be determined. In fact, it seems that the discordant results of the many investigators, and the failures in most cases to gain valid indications of the nature of fatigue, have

been due in a large measure to the failure to take into account sufficiently or correctly one or more of these factors.

Various tests have been devised for determining mental fatigue particularly as it concerns the work of the schoolroom. They may be divided into two main classes, physical tests and mental tests. The physical tests are concerned with pulse-volume and rate, respiration and blood pressure; ergographic and dynamometric tests of strength and muscular performance; tapping tests for rate and accuracy of movement; tests for measuring the accommodation of the eyes; and various others. Although much work has been done with each of these forms of tests and many valuable suggestions have been produced, criticism has shown them to be unreliable; and, at the most, they indicate fatigue, but do not give an absolute measurement of it.

Other tests, which as regards method are psychological rather than physiological, have been widely used and with somewhat greater success. Such tests take the form of measurements of cutaneous sensibility; of tactual discrimination; of other sensory values (algesic, auditory, visual, etc.); estimations of time; measurements of the duration of mental processes, such as the reading of certain groups of words; and the like. These tests have met with more favor and have given more satisfactory results than the physiological tests; although they, too, have failed to furnish anything like an adequate measure for fatigue.

The method of mental tests in the narrower sense aims to measure fatigue by determining the quality and quantity of mental work that can be done under varying conditions. The tests generally used are better adapted to the study of fatigue among school children, because they correspond more closely to the kind of work in which the pupils are regularly engaged.

The first investigator in this field was the Russian psychiatrist, J. Sikorski, in 1879, who used a form of dictation-test. The same general form of test, with improvements, was used later by Oehrn in 1889, Hopfner in 1894, Friedrich in 1896, and

by Binet and Henri in 1898. The nearly impossible task of obtaining a number of texts of uniform difficulty largely accounts for the unreliability of their conclusions.

The *Memory Method* of testing was devised by Ebbinghaus and has been used by Netschajeff, Schuyten and many others. Digits, nonsense syllables, logical sentences and other material has been used, but in most cases the results have not been satisfactory. The defect, however, has been in the method of conducting the tests rather than in the tests themselves; practise-effects have been permitted to conceal the effects of fatigue.

The *Completion Method,* also invented by Ebbinghaus, has been less widely used. In this test the subjects are required to fill in the blanks made by the elision of certain words and syllables in a simple text. The results obtained from this method have also been of doubtful value, chiefly for three reasons: (1) the inability to secure texts of equal difficulty; (2) the failure to eliminate practise-effects; (3) the failure to take account of individual differences among the subjects tested.

The *Cancellation Test* is another form frequently used in recent times. This method requires the subject to cancel, at greatest speed, one or more words, letters or digits from a printed text of properly arranged material. The chief source of difficulty in this test, it has been found, is to take account of the exceedingly great improvement due to practise.

The *Copying Method,* favored by Schuyten, consists in copying letters or digits which have been exposed on the board. The number of errors and corrections indicate the extent of fatigue.

The *Method of Simple Computations* has doubtless been more extensively employed than any other. Various forms of mental and written arithmetical computations have been used, and this test has the advantage of employing a mental function identical with an activity employed in the school. Another advantage of this method lies in the fact that different texts of almost uniform difficulty can be arranged. Never-

theless, in its use, the common difficulties presented by practise-effects and individual differences, are still to be met. Computations have been largely used by Kraepelin and his school especially in the *Continuous Work Method,* in which the subjects are required to work, unceasingly or with various prescribed periods of rest, for spaces of time varying from a few minutes to several hours. This method, if carried on with the same subjects for sufficient lengths of time to reach a stage in which practise-effects cease to be noticed, would certainly be an admirable one in many ways. It has been put to especially successful use by Kraepelin and his followers, by recording the work done within short (5-minute) periods, thus making it possible to plot a curve for the whole period. The method, however, is not without certain objectionable features. On account of the more than customary rigor and uniformity of the work, fatigue is likely to set in very early; in the beginning, also, practise-effects are large; the method is difficult to use in the school; and individual differences must be carefully eliminated.

The *Combined Method* has been favorably received and is preferred by Offner.[29] With this method, several tests for different functions are employed in succession, thus giving a more complete idea of the subject's general mental efficiency.

On the whole, although the last word on the question of fatigue is yet to be spoken and although we have no accurate measurement of fatigue or conclusive evidence of its nature, many important things have been accomplished: (1) Much has been done to standardize the forms of test and to show the defects in many methods of experimentation. (2) The factors which enter into fatigue and modify it in various ways, have been shown to be numerous and complex. (3) We now have evidence that real fatigue, at least as far as school work is concerned, has been greatly overestimated and that feelings of fatigue, lack of interest, and the like, are perhaps the chief

29 Offner, *Mental Fatigue* (1911), pp. 53-56

causes of diminution of the efficiency in the school room as the day progresses.

It is only reasonable to suppose, however, that any form of activity is fatiguing to some extent, although in many functions fatigue may be a minor element and completely masked by other factors. Fatigue, moreover, unquestionably varies greatly among individuals and is much more pronounced in some forms of work than in others. In the numberless industrial activities, the problem of fatigue is a vital one, and various studies in industrial efficiency have shown that the nature and amount of fatigue may be greatly modified by methods of work, rests, habits, drugs, food, etc.[30]

3. *Daily Habits of Life.*

The numberless habits of daily life have their effect on the diurnal course of efficiency. We may expect that the relative efficiency shown at any hour of the afternoon will depend to a considerable extent upon the amount and character of the work done in the forenoon, upon the hour of rising, the time and heartiness of meals, and upon many other self-imposed habits.

There is much reason to believe that the particular time at which a person is accustomed to work will come to be considered the most profitable. The student who persistently studies at night soon regards the evening as the most favorable period for mental work. Those whose heaviest work is ordinarily done in the morning, are likely to regard that as the most effective time. If they are interfered with, such habits, of whatever sort, seem to have great power to distract attention, and thus retard work. It is very probable that the disturbances in normal activity, following the breaking of a habit, such as the cessation of smoking, drinking, or of going without lunch, are quite as much due to the mental disturbance caused

30 See Münsterberg, *Psychology and Industrial Efficiency* (1913), especially chaps. 13-18.

by the failure to comply with the habit, as to the other effects of the lack of tobacco, liquor, or food.

The kind of work in which one is engaged—whether heavy or light, mental or physical—and the vigor with which one applies himself to it, are factors which influence the diurnal curve to a greater or less extent.

If reliable results are to be obtained concerning the diurnal course of efficiency, all such factors and habits must be taken into account. It is essential that their normal form and time of occurrence should be known, and it is equally important to know when variations from the habitual activities of the day occur, or when habits have not been complied with.

4. *Various Other Causal Factors.*

(1) *Sickness and Health.* Variations from the normal state of health would probably modify the normal course of efficiency to no small extent. For that reason, in experimental work, convalescent children or children feeling ill should be excluded.

(2) *Physiological differences in strength and endurance.* Persons vary in strength, endurance and susceptibility to fatigue. Given a day's work of a certain severity, we should expect some differences in the course of efficiency to appear from mere physiological differences.

(3) *Varitions in external conditions*, especially of the weather, may have some influence on the diurnal rhythm.

(4) *Sex.*—There is a possibility that the diurnal curve of efficiency differs slightly for the sexes. Marsh in his summary of investigations found frequent indications that the maximum for women occurred somewhat earlier in the day than for men.

(5) *Age.*—Previous investigators have found numerous instances in which the time of maximum efficiency for children appeared earlier in the day than in the case of adults, bidding us take into consideration any difference in age of the subjects used in research.

5. *Summary.*

It appears that the night rhythm of sleep is prolonged through the day, being felt in the earlier hours as a general condition of inertness, sluggishness or drowsiness, of varied intensity. The effects are most pronounced immediately after waking, and decrease gradually, although perhaps somewhat irregularly, as the day advances, the maximum of consciousness or wakefulness being attained usually in the latter part of the afternoon. This process of becoming awake is accelerated by the cumulative effects of successive internal and external sensory stimulation. This process of general adaptation continues upward, however, only to a certain point, when the catabolic processes, producing fatigue and lessening the activity of the nervous system, begin to reduce the efficiency of the organism.

It has been found, also, that the vital activities run almost the same course as that of consciousness during the day, although we are not prepared to say in just what manner these functions may be related.

The night-day rhythm of sleep and activity, the course of the vital activities, as well as of other functions, are undoubtedly modified in various ways by a number of factors. Fatigue ranks among the more important of these, and its effects vary with individuals and with the kind of work being done. As far as the work of the schoolroom is concerned, it is probable that *real* fatigue is a modifying factor of less import than feelings of fatigue, which—although they are but feelings—nevertheless usually succeed in reducing the quantity and quality of work. The time of going to bed and rising, of meals and rest, the method of working, and the like, also have their effects; and in case such habits are not complied with, there is a disturbance of greater or less magnitude in the course of efficiency. Varying conditions of health and sickness, differences in strength and endurance, and changes in external conditions may to some extent, modify the normal ebb and flow of efficiency.

This section, then, has given us: (1) A clue to the causal factors underlying the normal variations in efficiency; (2) an interest to discover how closely the course of efficiency in various mental and physical functions may resemble that of sleep and the vital activities; and (3) a caution that all modifying factors should be carefully taken into account.

III

Sources of Error with Regard to Material and Method

1. *Practise Effects.*—With any form of mental function, improvement due to practise is in most cases very large and in all cases it is noticeable. The diurnal variations of efficiency will, of course, be complicated with the progressive increase of efficiency due to practise, unless the latter factor is entirely cancelled or taken into account by some accurate means. It seems that the results of much experimental work, otherwise admirable, on the diurnal course of efficiency, fatigue, and kindred problems are rendered altogether of doubtful value because the effects of practise were not taken into account or were estimated and eliminated imperfectly. This point is too well known to need emphasis, but, in the work of various investigators which will be reviewed later, it has been so often neglected as to make it appear that their results should be accepted with caution.

2. *Unequal difficulty of texts* where a given test must be repeated with the same subjects. This difficulty, that of working out a series of equally difficult texts, is in some cases very grave. If in this form of work the subjects were to work at each succeeding hour with a different text, differences of considerable magnitude might often appear, which should be attributed solely to the greater ease or difficulty of the various texts. This difficulty is more serious in the *"Completion Test,"* for example, than in arithmetical tests.

3. *Individual Differences.*—Individuals differ in ability in

different mental functions as well as in the amount and rate of improvement from practise. Investigations which employ different groups of individuals for different steps in an experiment are subject to the difficulty of securing groups of identical ability, and of identical capacity for improvement. Thorough preliminary tests will greatly reduce this uncertainty, but will not in all cases entirely obviate it. The better plan would be to have the same subjects for all the tests, and to have the number sufficiently large to mask the effects of a few striking individual differences.

The factors just considered are by no means the only ones which are encountered in experimental work of this kind, but they are the ones which loom largest among the sources of difficulty. Other factors will be brought up and discussed as occasions arise.

IV

General Method of Experimental Procedure

In order to eliminate as far as possible the effects of practise, of differences in texts, and of differences in individual ability, the method now to be described was employed.

A class, consisting of about forty pupils on the average, was divided into five sections or squads, the number of the squads, for reasons which will be evident, being made equal to the number of hours in the school day. Each squad thus consisted of about eight pupils, and the personnel remained unchanged during the series of experiments. In the tests which required a different text for each experiment, five forms were used. A particular squad was given the tests but once each day, so it will be seen that in order to complete the round of hours, five full days were required to complete the experiment for any one class.

In detail, the work was conducted after the following manner: At 9. A. M. squad A was taken to a separate room and given Text 1 of all the tests, i. e., arithmetic, memory, etc., in a definite order which was preserved throughout the entire investigation.

At 10 A. M. squad B was given the same tests; at 11 A. M., squad C; and so, on through the day. The time required to complete at each sitting the entire eight tests given to each squad was a trifle less than half an hour. Consequently two classes could be handled each day by taking the squads from one class on the hours, 9 A. M., 10 A. M., etc., and those of the other at the half hours, 9:30 A. M., etc. This method was used throughout the work. On the succeeding day each squad worked one hour later than on the first day, the same progressive change being made on each succeeding day until each squad had worked at all the hours. A different text, of course, was used each day.

The table on page 23 may help to make the plan clear.

Each squad, it will be seen, works at all the hours, at one hour on each of the five days. Each squad completes all of the texts. Consequently the factor of differences in individual ability is avoided, for at each hour all of the students have been tested, and no one more than once. Practise effects are eliminated because the sum total of practise effects for any one hour is the same as for any other. The errors arising from differences in the difficulty of the texts are avoided, for each hour has to its credit one group working with each of the five texts.

The influence of pure fatigue, to whatever extent it may exist as produced by the regular work of the school, could not be avoided. There might have been some advantage in taking for subjects children who, previous to the hour of the test, had not been employed in physical or mental work of any sort; but such a program was impossible. The results, then, will show the variations during the day modified by the actual fatigue of the regular school work of the day, and perhaps for practical purposes such a measurement of efficiency will be of more value.

Thinking, however, that there might be much truth in the opinion of Thorndike[31] and others, that feelings of fatigue, ennui, loss of interest and the like are, in actual schoolroom life responsible to a greater extent for diminution of efficiency than

[31] Thorndike, E. L., "Mental Fatigue", *Psych. Rev.*, vol. 7 (1900), pp. 467–482, 547–579.

	Day 1	Day 2	Day 3	Day 4	Day 5	Total
9 A. M.	1st Squad 1st Trial Text 1	5th Squad 2nd Trial Text 2	4th Squad 3rd Trial Text 3	3rd Squad 4th Trial Text 4	2nd Squad 5th Trial Text 5	All Squads All Trials All Texts
10 A. M.	2nd Squad 1st Trial Text 1	1st Squad 2nd Trial Text 2	5th Squad 3rd Trial Text 3	4th Squad 4th Trial Text 4	3rd Squad 5th Trial Text 5	All Squads All Trials All Texts
11 A. M.	3rd Squad 1st Trial Text 1	2nd Squad 2nd Trial Text 2	1st Squad 3rd Trial Text 3	5th Squad 4th Trial Text 4	4th Squad 5th Trial Text 5	All Squads All Trials All Texts
1 P. M.	4th Squad 1st Trial Text 1	3rd Squad 2nd Trial Text 2	2nd Squad 3rd Trial Text 3	1st Squad 4th Trial Text 4	5th Squad 5th Trial Text 5	All Squads All Trials All Texts
2 P. M.	5th Squad 1st Trial Text 1	4th Squad 2nd Trial Text 2	3rd Squad 3rd Trial Text 3	2nd Squad 4th Trial Text 4	1st Squad 5th Trial Text 5	All Squads All Trials All Texts

is fatigue itself, it was thought desirable to eliminate such factors as far as possible.[32] This could be done only by creating such an interest among the pupils that those unpleasant feelings would for the time be absent or forgotten. As far as could be judged from appearances, this was accomplished. A very keen competition between individuals and between squads developed immediately, and there is every reason to believe that their work represents very nearly the best they were capable of doing.

Aside from pure fatigue, there are other possible factors whose effects could not well be avoided. Experimental research has produced considerable evidence that variations in efficiency occur during the week, the general indication being that the earlier days of the week are more favorable for mental work than the later.[33] Such a rhythm cannot, on account of the nature of the data in this research, be taken into account. Even if it be true, however, that one is more efficient on Monday than on Friday, it does not necessarily follow that a difference in the diurnal rhythm would result. The same might be said of the variations in efficiency which are said to occur during the year.[34] Mental work is said to be at its best during the months of October, November and December, and to decline in January, while physical efficiency reaches its maximum in the summer months. The present inquiry should show, at least, the nature of the daily variations in efficiency during the months of December, January, and February which persist in spite of the influ-

[32] Miller, W. S., *Journ. Ed. Psych.*, vol. 4 (1913), p. 241, in a review of "A Study of Mental Fatigue in Relation to the Daily School Program" (1913), by W. H. Heck, seems to believe that the tests there given by Heck are hardly adequate as an indicator of fatigue, because the high interest, which was apparently taken in the experiment made the activity one of recreation. To the present work, which aims to determine the time when children *can actually* do the most and best work and not the time when they *feel* like doing it, such a criticism could hardly apply.

[33] See Kemsies, F., "Arbeitshygiene der Schule auf Grund von Ermüdungsmessungen", in Schiller-Ziehen *Sammlung von Abhandlungen aus dem Gebiet der Pädagogischen Psychologie und Physiologie*, vol. 2 (1898), p. 64.

[34] For a summary of results bearing on this point see Meumann, E., *Vorlesungen zur Einführung in die Experimentelle Pädagogik* (Aufl. 1911), Bd. I, S. 126-132.

ence of the weekly or yearly rhythms, and in so doing may throw some light on the nature of the more extended variations.

The work of Winch has shown slight variations from the normal course of efficiency in the case of children who rise very early and do a considerable amount of work before school.[35] To discover such exceptional cases, as well as to obtain other information concerning the life and habits of the subjects, answers to the following questionaire were obtained:

1. Name of subject.
2. Address (number and street of residence).
3. Number of blocks from home to the school.
4. Does the subject walk, ride, etc., to school?
5. Age.
6. Amount and kind of outside work, if any, and time of doing it.
7. Time of going to bed.
8. Time of rising.

It was found that the hours of retiring and rising were on the whole quite regular, although the number of hours of sleep varied somewhat. It appeared however that most of the pupils obtained all the sleep they needed.

In this connection the data on the sleep of school children gathered by Terman and Hocking might be mentioned.[36] These investigators found in data from 1350 pupils varying in age from six to eleven years, that between the child's nervous traits and his sleep, between sleep and social status of the home, and between sleep and intelligence and school success, "there was practically no correlation, either positive or negative. This was true for every school subject and for every age." (p. 200.) This lack of correlation may be due, as Terman suggests, to the possible fact that most children sleep more than is necessary, or "that large quantitative differences in sleep may be fully offset

[35] Winch, W. H., "Mental Fatigue in Day Children as Measured by Immediate Memory", *Journ. Ed. Psych.*, vol. 31 (1912), pp. 18-28. Also, "Mental Adaptation During the School Day", *ibid.*, vol. 4 (1913), pp. 17-71.

[36] Terman, L. M., and Hocking, A., "The Sleep of School Children: Its Distribution According to Age, and Its Relation to Physical and Mental Efficiency", *Journ. Ed. Psych.*, vol. 4 (1913), pp. 138–147, 199–208, 269–282.

by qualitative differences." These results give us considerable assurance that there is little need to fear a large disturbance in the diurnal course of efficiency, due to the early setting-in of fatigue or early development of ennui because a particular child sleeps considerably less than does the average.

It is however, important to know concerning those individuals who sleep least, whether the sleep was cut off by early rising or by going late to bed; and, in the former case, what activities the child engaged in before the opening of school. As mentioned above, Winch in his investigations found that in the case of those children who arose very early and did a large amount of work before school, the hour of greatest efficiency during the forenoon was shifted considerably toward an earlier point in the morning. This may be due to two things: (1) The early workers by the time of the opening of school are more completely awake and better adapted to work, "have got into the harness," in short. (2) The effect of the longer hours of work (especially since the pre-school work is physical) results in rendering the children more susceptible to fatigue and feelings of fatigue in the later morning hours.

Such being the case, the records of the pupils were examined, with the result that only a very few were found who arose especially early and did a large amount of outside work before school. For the sake of greater accuracy, the work of these exceptional children was withheld from the final computations.

No definite information could be obtained concerning the effects of early morning work, by computing and comparing with those of the other subjects the results obtained from the few who arose early. Partly responsible for this is the fact that a comparison of the work of particular individuals in this series of experiments is very difficult and uncertain; because with any two individuals, unless they happen to be in the same squad, the results at any hour are confused with the effects of differing amounts of practise.

Taking together, however, the results obtained by Terman and Hocking and those of Winch it appears that the length of

time the child is awake before school, and the amount and kind of work done in that time, and not the mere amount of sleep obtained during the night, are the factors having an influence upon the course of efficiency. Consequently, the data from those pupils who went to bed late but also arose late, even though they obtained on the whole a relatively small amount of sleep, were not discarded.

A general average shows that the pupils sleep about ten hours; the younger ones, as a rule, sleep a little more than this, and the older ones a little less. Naturally individual differences, of greater or less magnitude, occur. The majority go to bed between 8 and 9 P. M., although many retire much later. The larger number rise about 7 o'clock, a few at 6 or 6:30, and many at 7:30, 8, or later. A few boys were found who arose at 5:30 and were at their posts with newspapers or in other work by 6. The average child spends the time before school in leisurely work—in housework, "chores", the practise of music, fancy work, making toys, etc., and in different forms of play.

With regard to differences between schools, the greatest regularity of retiring, of rising and of hours of sleep was found to be among the pupils of School "E," the opposite extreme being at School "W," with School "L" between. No differences of any consequence appear, however.

A glance at the figures showing the distances at which the pupils live from the school made it evident that the differences were insufficient to cause a perceptible variation in the results. Most of the pupils, naturally, come from the immediate neighborhood of the schools (within a radius of ten blocks) and nearly all the pupils who came a greater distance travel by street car, on bicycles or on roller skates. Moreover, most of those who lived nearby arrived at school early and took vigorous exercise in games.

Further information concerning the pupils was obtained from the teachers, who answered the following questions:

1. Is the pupil bright or dull, on the whole?
2. How does he rank in the particular subjects?

3. Is he lazy or energetic?
4. What is his disposition?
5. What physical defects has he?

With the aid of the information hereby gained, in addition to notes kept by myself during the work, justification was found for discarding the data of a few subjects. A close watch was kept upon the work of the pupils at all times, and since there were at most but eight subjects in a group, this could be done quite well. Any attempt on the part of a pupil to copy from another, any loafing, any use of improper methods of working—in fact, almost any failure to work according to directions—could be almost instantly detected. It was very pleasing, as well as fortunate, to discover that such "policing" was almost entirely unnecessary, and that such violations of method as occurred were in nearly all cases unintentional.

However, all factors which might result in unreliability of the data were urgently sought. When, for any reason, the work of a subject at any particular time was thought to be unreliable, the work of that student in that form of test was thrown out in whole.

The following are the chief factors which seemed to justify discarding a subject's work:

(1) *Absence from one of the tests.*—In case a pupil was absent from school for one or more days, the entire work was discarded. This was essential because in subsequent tests the pupil would have been a day or more behind in practise. In case a pupil missed one or more, but not all, of the eight different tests given on one day, the data of the particular tests missed was thrown out for the whole series. The absentees, however, on returning were allowed to continue the tests, although their work was not used. This was done merely to avoid all possibility of creating an ill feeling among the pupils.

(2) *Copying from others or using unfair methods of any sort.*—Such occasions, as I have said, were very rare. But where they occurred, only the data for the test in which the pupil was "caught in the act" were discarded, and not only for

that day but for all days. More common, but also very few, were the cases in which the pupils unintentionally used a wrong method. A few, for example, subtracted the multiplication problems or rushed through the drawing test too heedlessly. The work of such pupils was thrown out entirely for the form of test in which the mistake occurred.

(3) *Lack of interest or loafing.*—Occasionally a pupil from lack of interest or less worthy motives, felt inclined to be balky, to loaf or to "quit" for a moment in the midst of a test. Such work was thrown out in whole for the test concerned, but in every case the subject was brought back into good working order and the results in all the other tests were used.

(4) *Mental defectives.*—Several students were found who seemed, in the test work at least, to be distinctly below the normal in ability. Conferences with the teacher was held with regard to such pupils, and in every case they were found to be below the normal in the work of the schoolroom. The work of such pupils from all the tests was thrown out, although they were allowed to complete the work. In some cases pupils of average—indeed often of more than average—ability in most of the functions tested, made almost a complete failure in others. This was most noticeable in the case of the "completion test," foreign students, especially Chinese and Japanese, being generally unable to do the work there required. But only where the results were of such decidedly inferior quality that the amount produced was insufficient for adequate quantitative treatment, were they discarded.

(5) *Physical defectives.*—A few students were afflicted with myopia and other defects of sight, a few were weak from previous illness, and occasionally a pupil was handicapped by a bruised or cut hand, or by other minor accident. Whenever such defects were of a nature to interfere with a maximal performance, the data were excluded.

On the whole, the subjects were normal and their results were trustworthy. The total number of students in most classes was, as I have already said, from thirty-eight to forty. Of

these, the data of from thirty-three to thirty-eight appear in the final results. Of those which were discarded, the cause, in the majority of cases, was absence from school at one time or another during the course of the work.

V

The Subjects and Their General Home and School Environment

The subjects used in the investigation were pupils of the High and Low Sixth[37] Grades of two, and the pupils of the High Fifth[38] and Low Sixth Grades of a third Berkeley grammar school.

The three schools where the tests were made were situated in different parts of the city and the pupils were drawn in each case from a different neighborhood. School "E", the pupils of which were tested first, is filled with children who for the most part come from the homes of well-to-do business and professional men. The school itself is well fitted and ventilated; is provided with fairly ample playgrounds; and on the whole is considered among the best schools of the city.

In this school, the sewing-room on the lower floor was used for the experimental work. Abundant light was furnished by series of windows on two sides of the room and the room was kept at a moderate temperature by means of a hot-and-cold-air ventilating system. The room was spacious and each student was allotted a small table and chair for the work. The room was almost entirely removed from disturbing noises or distractions of any kind.

The first two days of experimental work at School "E"

[37] The "low" Sixth means the first half and the "high" the second half of the sixth school year or grade, the one class being just a half year in advance of the other.

[38] The High Fifth Grade was used at School W, because the High Sixth was not available for the work. The age of the pupils of all the schools varied from nine to fifteen years, the average for the Low Sixth being eleven and a half to twelve, for the High Sixth twelve to twelve and a half years.

(December 3 and 5, 1913), were somewhat cold in the early morning, the night before having in each case been nearly chilly enough for frost, but the days rapidly became moderately warm. The final three days of work, on account of examinations in the school, had to be postponed until December 10, 11 and 12. All three days were very disagreeable, with continuous heavy rain. The room, in which the tests were conducted, however, was warm and comfortable.

Since it is possible that the kind of work done by the pupils immediately before the tests may, on account of adaptation favorable or unfavorable, or for other reasons, have an influence on the result of the tests, the schedule of exercise is given below for those days during which the tests were given.

SCHEDULE OF EXERCISES OF THE LOW SIXTH GRADE, SCHOOL "E"[39]

9-9:30 A. M.	10:10-10:40 A. M.	10:40-11 A. M.	11:10-11:25 A. M.
Arithmetic	Grammar	Study Spelling	Spelling
11:25 A. M.-12 M.	1-1:30 P. M.	1:30-2 P. M.	2:10-3 P. M.
Music and Study	History	Reading	Geography and Study

Recesses occur from 10:00-10:10 A. M., 11:00-11:10 A. M. and from 2:00-2:10 P. M. An intermission of one hour is given between 12 and 1 o'clock. On the first two days (December 3 and 5), the weather being fair, the pupils played at various playground games during recesses. On the last three days, which were stormy, indoor games were played in the basement.

The pupils of the High and Low Sixth Grades of School "L", which is situated in the southern part of the city, were subjects for the experiments from February 3 to 12. School "L" draws its pupils chiefly from the homes of moderate means —of business people and skilled laborers. Aside from home "chores" and the like, very few of the subjects were doing outside work of any kind.

[39] Unfortunately, the copy of the program of the High Sixth Grade of this school was lost and owing to the fact that the teacher left in January, another copy could not be obtained. From all that could be learned, however, it seems to have been essentially the same as the above.

The school itself is very well fitted, lighted and ventilated; and there is ample opportunity for playground recreation. The experiments were conducted in a small library-room, which was well lighted and ventilated, the long table and chairs furnished for the work being entirely satisfactory.

Following is the program of studies for the days during which the tests were given:

Schedule of Exercises of the High Sixth Grade, School "L"

9-9:30 A. M. Geography	9:30-10 A. M. History	10:10-10:40 A. M. Music and Writing	10:40-11 A. M. Spelling
11:10 A. M.-12 M. Arithmetic	1-2 P. M. Drawing	2:10-3 P. M. Physical Culture, Gardening and Language	

Schedule of Exercises of the Low Sixth Grade, School "L"

9-10 A. M. Arithmetic	10:10-10:40 A. M. Study Spelling	10:40-11 A. M. Music and Writing	11:10-11:40 A. M. Language
11:40 A. M.-12 M. Reading	1-1:40 P. M. Geography	1:40-2 P. M. Spelling	2-3 P. M. Drawing and Physical Culture

The days on which the experiments were conducted at this school were Tuesday, February 3; Thursday, February 5; Tuesday, February 10; Wednesday, February 11, and Thursday, February 12. The first four days were warm and sunny; the last day was pleasant save for a few light showers which were not sufficient to prevent the children from spending their recesses out-of-doors. Three ten-minute recesses are given at this school; one each at 10, 11 and 2 o'clock.

School "W", in which the last series of experiments were conducted, although in a different part of the city, is situated in a general environment similar to that surrounding School "L". The pupils come chiefly from the families of moderate means—of business men and laborers. Several foreign students, chiefly Chinese and Japanese, were among the pupils of this school. They were found, however, to be among the best, both

in their school-work and in the tests with the exception of the "*completion test*". As was said, it was generally found necessary to discard their results in this one test.

School "W" at this time was very crowded, in fact the two classes tested were housed in two temporary single-room buildings which had been erected on the playground. Aside from this, the small buildings were comfortable, with light and air in abundance. On days of excessive heat, however, the children worked in their regular classes under some difficulty, and although the experiments were conducted in the earlier half of March, the afternoons of the two last days of the work were quite warm.

A small room fitted with ten regulation desks, on the second floor of the main building, was used for the testing. Everything was satisfactory, the situation of the room affording protection from the heat on the two warm days.

The experiments were conducted at this school on the following days: Thursday, March 5; Friday, March 6; Tuesday, March 10; Thursday, March 12, and Friday, March 13. The first three days were warm and pleasant; the last two, as has been said, were a little too warm for comfort.

The schedule of exercises is given below:

SCHEDULE OF EXERCISES OF THE HIGH FIFTH GRADE, SCHOOL "W"

9-10 A. M. Arithmetic	10:10-10:30 A. M. Reading	10:45-11:30 A. M. Geography	11:30 A. M.-12 M. Writing
1-1:30 P. M. Drawing	1:30-2 P. M. Grammar and Composition	2-2:30 P. M. History	2:30-3 P. M. Spelling

SCHEDULE OF EXERCISES OF THE LOW SIXTH GRADE, SCHOOL "W"

9-10 A. M. Arithmetic	10-10:30 A. M. Spelling	10:30-11 A. M. Grammar	11-11:30 A. M. History
11:30 A. M.-12 M. Geography	1-1:30 P. M. Music	1:30-2 P. M. Study and Reading	2-3 P. M. Study

Differing from the other schools visited, but one recess is

given in the morning at School "E", a ten minute recess from 10:30-10:40 A. M., and no recess is given during the afternoon session.

VI

Materials, Methods, and Results of the Tests

1. *Tests in Addition*

(1) *Material used.*—Computation tests have long been favorites in many lines of experimental work, especially in fatigue, mainly because they demand the exercise of a variety of mental processes. In fact, arithmetical tests have not seldom been considered as a fair test for general mental efficiency. At the present time, however, they are not considered as such, but merely as a measure of efficiency in a rather difficult and practical sort of mental activity.

The solution of problems in addition [illegible] on i[illegible] dependent chiefly upon the activity and accuracy wit[illegible] which certain associative processes are executed. Attention, [illegible]scrimination and memory are of course involved, and in the [illegible]ase of written work other subsidiary processes, such as visual perception and motor activities. Investigators have made extensive use of such computation tests in attempts to determine the curve of fatigue, mental efficiency, and the work curve (Arbeitskurve). Among the many are Bellei, Burgerstein, Ebbinghaus, Friedrich, Heck, Holmes, Keller, Kemsies, Lasar, Marsh, Schulze, Teljatnik, Thorndike, Kraepelin and his school, and Winch.

Since it was desirable in this investigation to have th[illegible] arithmetical tests as similar as possible to the actual work [illegible]f th[illegible] school, the written form of addition has been used. Fort[illegible] problems, five rows of eight problems each, were printed in [illegible] poin[illegible] type on a sheet $8\frac{1}{2}$ by 11 inches. A vertical column [illegible] thre[illegible] 2-place numbers constituted a problem. The repetition of th[illegible] same digits in a single column was avoided and the problem[illegible] were made, in general, of as nearly equal difficulty as possibl[illegible] Five different texts of the same sort were made, so that the sul

jects worked with a new set at each of the five tests which they went through. A portion of the problems from the first text is printed below:

ADDITION. SET 1

46	91	42	23	45	25	48	93
85	89	38	18	76	73	83	57
24	13	99	87	18	64	76	19
—	—	—	—	—	—	—	—
47	28	25	99	49	19	46	23
93	56	36	85	56	28	75	38
86	34	83	58	84	75	87	99

(2) *Details of the method of conducting the tests.*—The papers were placed face downward on the subjects' desks and the following instructions were given: "On these papers are printed a number of very simple problems in addition. When the signal is given, you are to add up the problems as quickly and accurately as possible. Be careful about making errors; do as many problems in the time allowed as you possibly can."

At the signal "Ready", the subject took the right edge of the paper (which was face downward) with his left hand, holding the pencil ready for action, in the right. At the word "Go" the papers were quickly turned over and the work of computing started. Two minutes were allowed for the test, time being kept with a stop-watch. The signatures, date, hour and class were written on the paper after the completion of the test.

(3) *Treatment of data and computation of results.*—The results were scored by giving a credit of 1 for each single column correctly added. For an accurate solution of one whole problem, manifestly, a credit of 2 was obtained. This method was used, because it was often found that a mistake in the first column of a problem caused an error in the second column due to the "carrying" of an incorrect amount, and by the use of this method the mis-counting of such errors could be avoided. It is evident, however, that to allow the same credit for the correct addition of the first as for the second column is not

strictly right, for in the second column four digits are added, i. e., the three in that column and the one "carried over" from the first. For the present purpose, since the effect at all the hours was the same, the method seems to be accurate enough.

The results given below show the average number of columns added at different hours of the day. The results, to be more exact, show the average of the averages of the five squads for each of the hours. The work of many students, for various reasons which have been cited, was rejected and often the number of subjects finally remaining in some squads was much less than in others. Since, considered from the point of view of any particular hours, the practise effects of each squad differed from every other, to permit the results of a squad including a greater number of individuals to enter the final average with full weight would distort the figures in a degree amounting to the average difference in efficiency due to the greater amount of practise of the one over the other. This overweighting was prevented by averaging each squad separately and then making a final average of those of each of the five groups.

TABLE I

Showing the Average Number of Columns Added by Classes at Different Hours of the School Day[40]

Class	*9 A. M.	10 A. M.	11 A. M.	1 P. M.	2 P. M.
E. a6	32.04	32.54	32.94	32.34	32.74
L. a6	28.32	29.84	30.06	29.46	29.82
W. a5	26.76	26.92	27.60	27.28	27.40
	9:30 A. M.	10:30 A. M.	11:30 A. M.	1:30 P. M.	2:30 P. M.
E. b6	29.20	29.66	29.88	29.32	29.58
L. b6	25.98	26.04	26.96	26.50	26.62
W. b6	31.90	33.32	34.02	33.26	33.26
Average of six classes	29.03	29.72	30.24	29.69	29.90
Average efficiency, per cent	100.	102.4	104.2	102.3	103.

*In this and the following tables, the time given is approximately the time the test was begun.

[40]Since one credit was given for each column added, the numbers in the table equal twice the number of problems correctly solved.

(4) *Results.*[41]—For addition, the tables and figures show a marked and steady increase in efficiency from the first to the last morning hour, where the maximum occurs. Following the lunch

9-10 A. M. 10-11 A. M. 11 A. M.-12 M. 1-2 P. M. 2-3 P. M.

E a6

L a6

W a5

E b6

L b6

W b6

Av.

Fig. 2. Showing variations in efficiency for addition at different hours of the day.

hour, a decided drop is noted and a final upward movement of efficiency during the last afternoon hour. The curve, in its gen-

[41] It is to be understood in this and in subsequent sections that when an hour or period (9 A. M., etc.) is spoken of, it includes all tests given from that hour to the one following. Thus the 9 A. M. period extends from 9–10 A. M., etc.

eral form, is alike for all the six classes. In every case the minimum is in the 9 A. M. period, with the maximum occurring in the 11 A. M. period. The 2 P. M. period is generally, but not always, higher than the 10 A. M. period in point of efficiency. In all cases, a drop occurs at 1 P. M. as compared with 11 A. M. or 2 P. M., with the exception of class W. b6,[42] in which the efficiency for the two afternoon hours is identical.

On the whole, the curves of efficiency in addition for children of six different groups, in three different schools, living under somewhat different environment and produced under different weather conditions, show a striking resemblance to one another and to the average curve.

A discussion of these results in comparison with those of previous investigators will be presented in the next section in conjunction with those of multiplication.

2. *Tests in Multiplication*

(1) *Material used.*—As in the addition test, written problems of a simple form were used. The problems were printed on a page, size 8½ by 11 inches, containing six rows of nine problems each. Each problem consisted of a 2-place multiplicand and a 1-place multiplier, made by combinations of all the digits except 5 and 0, which were omitted on account of the greater ease with which they enter into computations. Five different texts, one for each performance was prepared. A portion of the problems from the first text is appended:

MULTIPLICATION. SET 1

26	39	42	63	74	93	87	48	36
7	4	9	3	7	8	6	3	4
28	96	47	64	39	23	34	43	63
3	4	6	7	8	9	8	9	7
47	98	87	34	83	96	46	34	26
6	4	3	6	4	3	7	8	9

[42] The letter *b* is used here and will be used hereafter to designate the "low" and *a* to designate the "high" class of a grade. Thus W. *b6* means the Low Sixth Grade of School "W".

(2) *Details of the method of conducting the tests.*—The method used in this test was essentially the same as that employed in the addition test, just described. Two minutes time was allowed for the test.

(3) *Treatment of the data and computation of results.*—The method of scoring results was similar to that used in the case of addition. A credit of 1 was given for an accurate computation of each of the two separate processes involved in the problem; thus a whole problem accurately computed would be credited as 2. Erroneous answers in the second half of the problem, due to the "carrying over" of a wrong number which resulted from the mistaken computation of the first part, would not be counted against the subject.

TABLE II

SHOWING THE AVERAGE SCORE RECEIVED IN MULTIPLICATION AT DIFFERENT HOURS OF THE DAY*

Class	9 A. M.	10 A. M.	11 A. M.	1 P. M.	2 P. M.
E. a6	40.36	41.16	43.72	41.00	42.82
L. a6	36.42	37.30	38.01	36.52	37.42
W. a5	34.92	34.90	36.16	34.74	35.66
	9:30 A. M.	10:30 A. M.	11:30 A. M.	1:30 P. M.	2:30 P. M.
E. b6	36.14	36.90	37.78	37.14	37.16
L. b6	31.48	32.24	33.64	31.98	32.14
W. b6	36.06	36.88	37.16	35.82	36.62
Average for six classes	35.89	36.56	37.74	36.20	36.97
Average efficiency, per cent	100.	101.9	105.1	100.86	103.

*To obtain the number of problems correctly worked, divide these numbers by two.

(4) *Results.*—The final results were computed, as in the case of addition, by taking a final average of the averages of each of the five squads. The table below is given in the form of the average number of credits obtained, which amounts to twice the actual number of problems actually worked.

The course of efficiency for multiplication is in all essentials

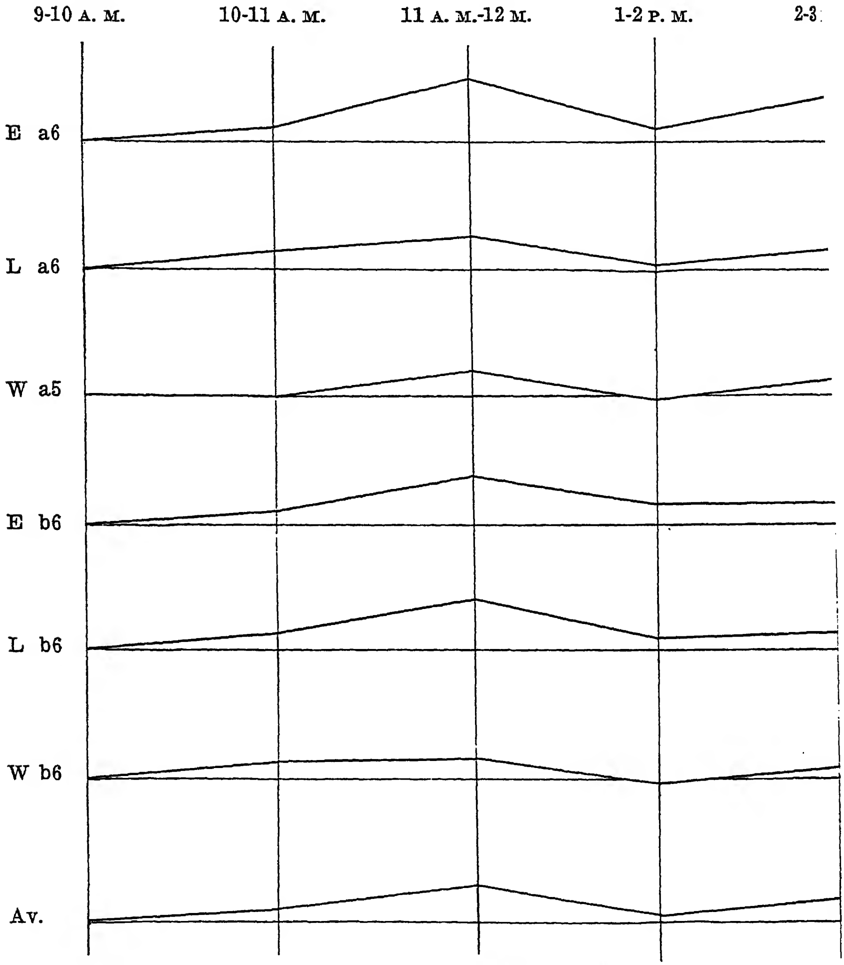

Fig. 3. Showing the diurnal course of efficiency in multiplication.

the same as that for addition. There is, however, somewhat greater variation among the individual classes, and the variations from the average curve are slightly greater. The minimum efficiency is found, with two exceptions (W. a5 and W. b6), at 9 A. M.; the maximum of efficiency is found to be in all cases at 11 A. M. Class W. a5 is different from the other classes in that it fails to show a superiority of 10 A. M. over the 9 o'clock hour.

The average superiority of 5.1 per cent which the maximum hour shows over the minimum in multiplication, is 0.9 per cent greater than the same difference in the case of addition. The one other difference noted between the average curves for the two forms of computation is, that addition shows a higher efficiency at 1 P. M.

(5) *The diurnal course of efficiency found by previous investigators in computation-functions.*—Roemer,[43] as reported by Weygandt, in experiments of eight days' duration, on the effects of food, using half-hour addition tests on alternating days with and without breakfast, found the following results, which are given in percentages of the efficiency shown at the first hour:

With Food				Without Food			
9 A. M.	A. M.	11 A. M.	12 M.	9 A. M.	10 A. M.	11 A. M.	12 M.
100	97	91	89.5	100	87	84	90

In either case, a steady decrease in efficiency is shown during the forenoon. These results stand in striking contrast to my own and to most of those which follow.

The extensive work of Thorndike[44] on mental fatigue may be briefly alluded to here. Experiments were conducted upon adults and children at different times of the day, both when the subjects were fresh and well rested and when they reported feelings of fatigue. In school-room work at Cleveland, Ohio, and at Scranton, Pennsylvania, 750 pupils were tested in multiplication, a half of the number just after school opened and the other half just before the close of school. Thorndike found that the latter group did 99.3 per cent as much work with 103.9 per cent as many mistakes as the former and fresher group. The conclusions drawn by the investigator were to the effect that feelings of fatigue are no measure of mental inability and that "mental fatigue does not come in regular proportion to the

[43] Weygandt, "Roemer's Versuche über Nahrungsaufnahme u. geistige Leistungsfähigkeit", *Psych. Arbeiten*, vol. 2 (1899), pp. 695–706.

[44] Thorndike, "Mental Fatigue", *Psychological Review*, vol. 7 (1900), pp. 466–482, 547–579.

work done''. Thorndike's belief is that boredom rather than fatigue is the cause of diminution in work as the day progresses. The pupils become tired of work rather than tired by work. It will be seen at once that these results differ widely from those of Roemer, just given, but are not greatly different from my own. It is possible that the competitive factor—a sure cure for feelings of fatigue—was less keen in Thorndike's work, and that this may account for the greater efficiency at the later hours in the classes I tested.

Marsh[45] in multiplication tests, using 2-place numbers with one subject for four days, found the following, expressed in time, per centage of errors, and number of mistakes made:

7 A. M.			8:30 A. M.			10 A. M.			11:30 A. M.		
Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.
37.6	2.4	.50	34.7	1.6	.50	39.7	2.5	.63	41.8	1.7	.50

1:30 P. M.			3 P. M.			4:30 P. M.			6 P. M.		
Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.
48.0	2.6	.70	45.3	2.6	.83	41.0	1.8	.60	47.1	2.4	.71

A morning maximum is shown, with the afternoon hours at a low ebb of efficiency. This curve, however, is that of a particular individual, a university graduate student, whose habits of life may loom large among the factors here at work.

The same writer, however, in tests of addition using ten columns of fifteen figures each, with a larger number of subjects, found quite different results, as the following table will show:

[45] Marsh, H. D., *op. cit.*, p. 54. Pp. 1–99.

TABLE III

ADDITION:—COLUMNS OF 15 FIGURES. (From Marsh, p. 54)

SUBJECT	Total number of columns	7-9 A. M.			12 M.-2 P. M.			5-7 P. M.			9-11 P. M.		
		Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.
I	140	99.4	1.00	1.2	91.9	0.91	0.6	92.6	0.86	1.4	97.0	0.89	0.9
II	120	110.2	1.11	0.8	99.1	1.44	0.7	106.9	1.32	0.9	109.2	1.67	1.1
III	120	89.5	1.28	1.0	87.3	1.13	0.7	86.0	0.90	0.7	85.3	0.90	1.5
IV	100	66.3	0.55	0.6	64.7	0.78	0.8	63.6	0.78	0.6	69.2	1.52	0.6
V	120	105.2	0.99	1.3	90.8	0.81	0.6	99.2	0.88	1.0	98.8	0.69	1.2
VI	100	122.2	1.78	1.1	119.4	1.81	1.4	123.0	1.58	1.0	116.9	1.79	1.2
Average	117	98.8	1.11	1.0	92.2	1.15	0.6	95.2	1.06	0.9	96.1	1.24	1.08

The maximum is found in the midday period followed by a decrease of a little over three per cent from 5–7 P. M., the minimum occurs in the morning period. Accuracy follows the same course as speed. In a general way, the course of efficiency here is similar to those shown in Table II.

Marsh's revision of Rice's tabulations of results, obtained from examinations in arithmetic of the students in thirty-eight schools in several cities, shows that the schools examined in the morning show superiority over those examined in the afternoon.

Morning:	Work Correct	Principle Correct	Mechanical Errors
Average of eight schools..........	60.0	64.4	7.4

Afternoon:	Work Correct	Principle Correct	Mechanical Errors
Average of eight schools..........	43.7	49.3	12.1

But this difference may be due mainly to differences in the ability of the students of the schools tested. Marsh says, for instance, "the best cities were tested mostly in the morning, and the poorest in the afternoon."[46]

Winch[47] in arithmetical tests with two-hour-session evening schools has shown that the work done at 8 o'clock is 25 per cent better than that at 9 o'clock. Fatigue at the later hour appeared to have completely masked the effects of improvement by practise during the session. A point of interest noted by Winch lies in "the complete disagreement of the results with those which would have been furnished by a questionaire" and with the opinions of the instructors, who believed that the mental capacity of the students improved as the evening wore on. They were, perhaps, as Winch suggests, "misled by the greater *appearances* of interest and mental excitement which is itself an indication of approaching fatigue." (p. 17.)

Other experiments by the same writer upon pupils of one-

[46] *Ibid.*, p. 58.

[47] Winch, W. H., "Some Measurements of Mental Fatigue in Adolescent Pupils in Evening Schools", *Journ. Ed. Psych.*, vol. 1 (1910), pp. 13–23, 83–110.

hour-session evening schools, led him to conclude that "evening work is comparatively unprofitable, and that a short time in class in the evening is sufficient, plus the labors of the day, to induce a very low condition of mental energy."

In a later series of experiments,[48] Winch divided large classes into two sections and tested them with arithmetical reason problems at two different periods, one early and one late in the forenoon. The average ability of the two sections was made, by virtue of preliminary tests, as nearly equal as possible. It was found that the classes working later in the forenoon excelled by five to six per cent those working earlier. This was true of all but one school—a school of poor boys who rose early and worked before school—in which case greater efficiency was found early in the morning session.

These results, so far as they go, are in almost exact agreement with those found in the present investigation.

Robinson[49] found results similar to those obtained by Winch, showing a noticeable "warming up" effect in the early morning, especially with older children. Robinson also found evidence of a gradually increasing efficiency up to a maximum at about 10:30 A. M., followed by a drop most noticeable at 12:30, and then by an increase of efficiency up to the time of the close of school at 2 P. M. The same writer found, as had earlier investigators, the superiority of a ten to fifteen minute recess over a longer one; the longer recess causing a loss of efficiency in the work which immediately followed.

Heck,[50] in a study of mental fatigue in which a modification of form No. 7 of the Courtis tests was used, tested 11[illegible] boys and girls in the fifth and sixth grades of the New York schools. The test consisted of three examples each of addition, subtraction, multiplication and division, and were given approximately

[48] Winch, "Mental Adaptation During the School Day", Journ. Ed. Psych., vol. 4 (1913), pp. 17-28, 71-84.

[49] Robinson, L. A., "Mental Fatigue and School Efficiency", Winthrop Normal and Indus. College of S. C. Publ., vol. 5 (1912), no. 2, p. 56.

[50] Heck, W. H., *A Study of Mental Fatigue in Relation to the Daily School Program* (1913), p. 28.

at the hours of 9:10 A. M., 11:05 A. M., 1:10 P. M., and 2:30 P. M. The following table shows the results in percentile differences based on the efficiency of the first period:

	9:10 A. M.	11:05 A. M.	1:10 P. M.	2:30 P. M.
Quantitative differences....	100.	101.57	101.64	102.36
Qualitative differences.......	100.	98.49	98.59	97.72

Quantitatively a steady increase and qualitatively a steady decrease takes place during the day.

In a second study,[51] the same investigator tested 573 children, with an average age of 12.55 years, in the fifth, sixth and seventh grades of four schools of Lynchburg, Virginia. The subjects were arranged in two groups, each of which was tested with 25-minute tests, once in the morning between 9 and 10 o'clock and once in the afternoon (1 to 2 o'clock). Following is a summary of the results:

	Morning Period	Afternoon Period
Amount of work done....................	22.91	23.18
Relative amount done....................	100.00	101.18
Per cent right..................................	72.46	70.23
Relative per cent right..................	100.00	96.92

The results here are essentially in agreement with those obtained from the New York schools.

In a third study[52] Heck employed reason-problems in arithmetic (Forms 1 and 3 of the Courtis Standard Test, No. 8) with sixteen classes of the high and low sixth grades of a Roanoke, Virginia, intermediate school. Twelve-minute tests were given at two periods, 9:25–10:30 A. M. and 12:50–1:55 P. M. With regard to the results, Heck makes the following statement: "The number of examples done in the afternoon was 0.68 per cent

[51] Heck, W. H., "A Study of Mental Fatigue in Relation to the Daily School Program," *Psych. Clinic*, vol. 6 (1913), pp. 29–34.

[52] Heck, W. H., "A Third Study of Mental Fatigue in Its Relation to the Daily School Program", *Psych. Clinic*, vol. 7 (1914), pp. 258–260. The same results are given under the title, "The Efficiency of Grammar-Grade Pupils in Reasoning Tests in Arithmetic at Different Periods of the School Day", *Journ. Ed. Psych.*, vol. 5 (1914), pp. 92–95.

greater than in the morning; the per cent of examples right in the afternoon was 3.22 per cent less than in the morning.'' His results are summarized in the following figures:

	Morning Period		Afternoon Period	
	Examp. Comp.	Examp. Right	Examp. Comp.	Examp. Right
467 subjects	5.85	4.31	5.89	4.20

	Morning	Afternoon
Relative number done	100.00	100.68
Relative number right	73.68	71.31
Per cent right	100.00	96.78

The inference Heck draws from his extensive researches is given in the words: ''Normal healthy children of the grammar grades, in a hygienic school environment, can meet the requirements of the usual daily school program without injury to themselves or their work.'' (p. 95.)

To compare the figures of Heck with those of the present work, only the precentage of problems correctly done should be considered, since in the present results, no account is given of the total amount of work done. When we consider that Heck's afternoon tests in some cases began as early as 12:50 P. M. and that those of the morning ran as late as 10:30, the results of the two investigations seem to be in harmony. The present work shows perhaps a slightly greater efficiency for the afternoon hours, and, on the whole, bears out very strongly the conclusions stated by Heck in the quotation just given.

Hollingworth[53] tested fifteen adult subjects for ten days, under conditions unusually favorable for experimental control. Previous practise of more than a week served to bring the subjects down to the secondary slope of the practise curve. The subjects were undergraduate and graduate college students and their wives, who were ''regular employees, working for wage'', and ''under oath to do their best.'' Seven tests were given in series, of which the calculation test was the fifth, at five periods during the day. The test consisted in adding mentally 17 to

[53] Hollingworth, H. L., "Variations in Efficiency During the Working Day", *Psych. Review*, vol. 21 (1914), pp. 473–491.

50 two-place numbers in chance order. Following are the average results of each of the three groups into which the total number of subjects (15) were divided:[54]

	7:45 A. M.	10 A. M.	12 M.	3:10 P. M.	5:30 P. M.
Average of 5 men	100.	98.5	94.5	93.2	89.2
Average of 5 women	100.	98.5	96.5	95.1	92.3
Average of 5 men (irreg.)	100.	98.6	100.2	97.6	96.2

Experiments with the same tests upon ten subjects working for twelve hours on two days, starting at 10:30 A. M. and with a rest period 12:45–1:30 P. M. and another of equal length at 6 P. M., gave results as follows,[55] expressed in time and percentages of error:

Time	10:30 A. M.	11:15 A. M.	12 M.	1:30 P. M.	2:15 P. M.	3. P. M.[56]
Average time	86.1	84.8	86.9	85.8	86.6	87.9
Per cent error	2.1	2.8	2.8	2.3	2.2	2.5
Per cent efficiency	100.0	101.0	99.0	100.0	99.0	98.0

The maximum appears in this case at 11:15 A. M., while in the preceding figures, with the exception of the one group which showed a high efficiency at 12 M., efficiency was comparatively low in the late forenoon. The results of the more extended experiments agree fairly well with the results I have obtained with school children, but the results of the preliminary experiments, with longer intervals between hours of tests, are contrary to the data here found. There are many reasons, however, which might lead one to expect different results from the two investigations. In the first place, Hollingworth employed as subjects adults, for whom special habits of life might loom large

54 These figures are estimated from the curves given in the article and are stated in percentages of efficiency of each hour compared with the first, rather than in terms of relative amount of time as plotted in the original.

55 The results here are given in percentages of efficiency of every period on the basis of the initial performance, rather than in the reverse figures (relative amount of time required compared with that of the first period) employed by Hollingworth.

56 Later periods running to 10:15 P. M. are not considered here.

as determining the course of efficiency. Note, for example, that in the more extended experiment, the results of which were given last, the group worked continuously until 12:45 P. M. If such were not the custom of the subjects, disturbances in efficiency would be expected. And if it were their custom, the course of efficiency during the hours that follow could scarcely be safely compared to the results obtained from children or others with entirely different habits.

Moreover, it appears to the writer that Hollingworth's tests in some cases are so involved with general fatigue and feelings of fatigue, and more especially with fatigue from the tests themselves, that an adequate measure of diurnal variations of efficiency can not be expected from them. In the case of the continuous work experiments, the effect of these factors cannot be questioned. With regard to the first part of the experiment in which the tests were given at each of five periods, Hollingworth says "five trials were made daily, each sitting requiring about 45 minutes". He is evidently speaking here of only the seven tests which were used for computation in the latter article, for in the earlier article, which describes in detail the experiments from which the data were obtained, he says "the subjects went through the tests five times a day (each time requiring about one hour)".[57]

Fatigue and feelings of fatigue of considerable extent might easily result from maximal application to trying work of such length. There is, moreover, some evidence from the results obtained by Hollingworth that this is the case. The functions which were first tested show a comparatively high efficiency for several hours following the first period, but those functions which were tested in the latter part of the series are the ones which shortly show a low efficiency relative to that attained at the first hour.

[57] "The Influence of Caffein on Mental and Motor Efficiency", *Arch. of Psychol.* (1912), no. 22, p. 8.

3. *Tests in Auditory Memory*

(1) *Material used.*—For a test of auditory memory, series of eight digits were used. The following were the numbers employed: 4 6 2 9 8 7 1 3, 5 8 4 9 3 7 6 1, 5 9 7 8 0 2 4 3, 3 6 2 1 4 8 9 2, 3 8 4 6 9 1 3 7.

(2) *Method of conducting the tests.*—Instructions as follows were given: "I am going to read to you a series of eight digits. You are to listen attentively and as soon as the numbers have been read, write them down on the card in the order in which they were given."

The digits were read at the rate of one per second, with an attempt to ensure even tempo, clear articulation, and freedom from rhythm. This test was always given as the third of the series.

(3) *Treatment of data and computation of results.*—The results were scored by counting the number of digits which were correct and in correct position. A digit was considered as being correctly placed when it was in a correct relative position, measured either from right to left or left to right. This method is not as accurate, on the whole, as some of the more complicated systems of scoring, but errors developed only on rare occasions and since this work is not concerned especially with individual results, and demands only that the method should be as fair for one hour as for another, it was used because it proved to be convenient.

The final averages were computed by combining the averages of the several groups, as in the previous tests.

(4) *Results.*—The tables and curves show, on the whole, a variation in efficiency similar to that found in addition and multiplication. The curves for the various classes, however, show considerably greater variations among themselves and from the average course. The maximum efficiency appears at the 11-A. M. period in four out of the six classes; in one of the exceptional classes (E. b6) the maximum occurs at 10:40 A. M. and for the other (W. b6), 2:40 P. M. appears to be the best hour, but it is, however, only slightly superior to 10:40 A. M. The

9 A. M. minimum is found in four of the six classes, but a very large drop at the 1 o'clock period brings the efficiency of two of the classes at that hour to a lower level than is found in the morning. In the case of L. a6, the inferiority amounts to 8.1 per cent; in the case of E. b6 to 7.5 per cent. The magnitude of these two unusual drops in efficiency was sufficient, notwithstanding the fact that the case was otherwise with the other four classes, to bring the general average of 1 P. M. below that of 9 A. M. In every case save one (L. a6), 10 o'clock is superior to 9 o'clock, and in all cases a greater efficiency is attained at the 2 o'clock period than at 1 o'clock.

The general course of efficiency, as shown by the average curve, takes the form of a gradual increase during the forenoon, the total improvement during that time amounting to over six per cent, followed by a fall at 1 o'clock and a subsequent rise until 2:40 P. M.

TABLE IV. MEMORY FOR AUDITORY DIGITS

SHOWING THE AVERAGE NUMBER OF DIGITS CORRECTLY REPRODUCED AT DIFFERENT HOURS OF THE SCHOOL DAY

Class	9:10 A.M.	10:10 A.M.	11:10 A.M.	1:10 P.M.	2:10 P.M.
E. a6	4.75	4.90	5.04	4.94	4.98
L. a6	5.98	5.92	6.36	5.50	5.90
W. a5	4.88	5.44	5.56	5.10	5.38
	9:40 A.M.	10:40 A.M.	11:40 A.M.	1:40 P.M.	2:40 P.M.
E. b6	4.54	4.92	4.78	4.20	4.68
L. b6	4.78	4.96	5.14	5.02	5.08
W. b6	5.70	5.88	5.76	5.80	5.90
Av. of six classes	5.10	5.40	5.44	5.07	5.22
Average efficiency, per cent	100.	105.9	106.7	99.41	102.4

4. *Tests in Visual Memory*

(1) *Material used.*—A series of eight digits, which were exposed all at once, was used as a test of visual memory. The series used were: 8 3 5 7 0 4 6 7, 4 6 3 1 2 7 5 8, 5 9 7 8 0 2 4 3, 2 7 9 8 6 5 4 3, 4 0 2 6 2 3 8 7. These were of black digits 2¾ inches in height, each on a white card 2½ by 3½ inches in size and the eight in series on a strip of gray cloth.

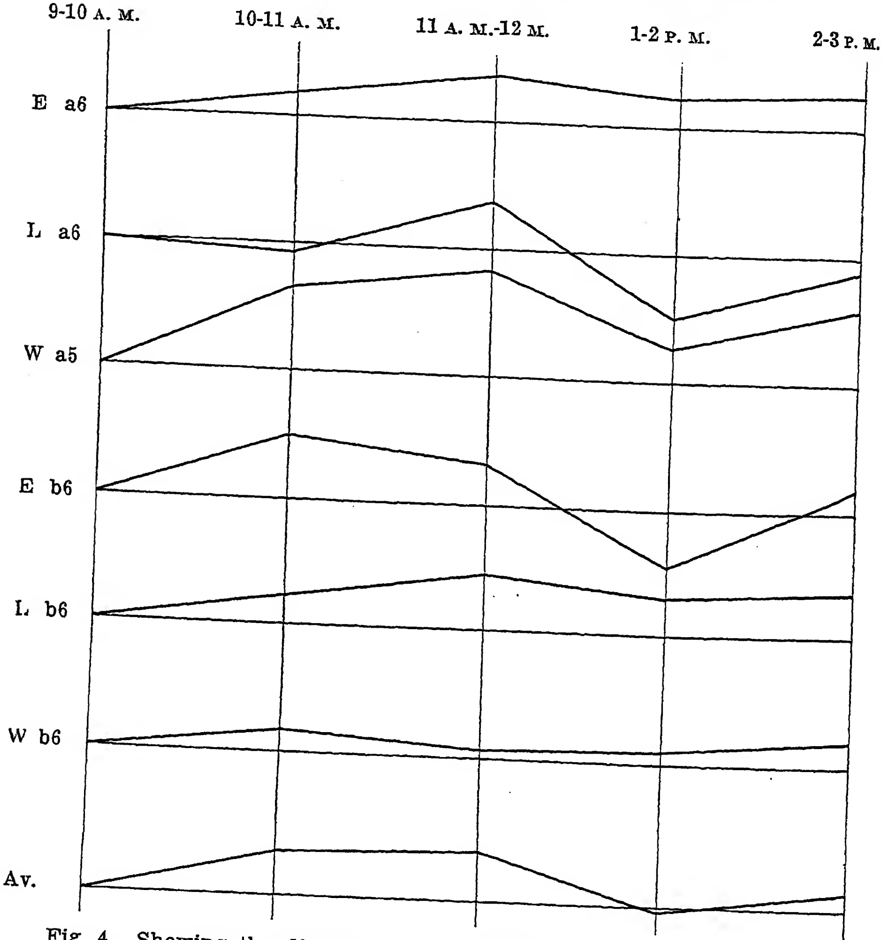

Fig. 4. Showing the diurnal curve of efficiency in memory for auditory digits.

(2) *Method of conducting the tests.*—The folded strip containing the digits was held before the pupils, and at the word "now" the strip was quickly drawn taut exposing the digits. The pupils had previously received the instructions: "You will be shown a series of eight digits which you are to study until they are taken from view. As soon as they are taken from sight, write down as many of them as you can remember on your card,

giving them in their proper order." The digits were exposed for eight seconds and as soon as the numbers had been written, the subjects turned their cards face downward.

(3) *Treatment of data and computation of results.*—The data were treated and the results computed as in the test for auditory digits.

(4) *Results.*—It is evident that the course of efficiency for memory of visual digits is very similar to that for auditory digits. There is, however, less regularity among the groups in the case of visual memory. The highest degree of efficiency is reached in all classes in the 11 o'clock period, while the minimum appears in three cases at 9 A. M. and in three at 1 P. M. Two o'clock is in three cases superior and in three inferior to 10 o'clock, the average efficiency in each case being about the same.

TABLE V. MEMORY FOR VISUAL DIGITS

SHOWING THE AVERAGE NUMBER OF DIGITS CORRECTLY REPRODUCED AT DIFFERENT HOURS OF THE SCHOOL DAY

Class	9:10 A.M.	10:10 A.M.	11:10 A.M.	1:10 P.M.	2:10 P.M.
E. a6	5.24	5.40	5.44	4.92	5.32
L. a6	6.08	6.14	6.16	5.72	5.82
W. a5	5.08	5.54	6.40	5.54	5.56
	9:40 A.M.	10:40 A.M.	11:40 A.M.	1:40 P.M.	2:40 P.M.
E. b6	5.26	5.38	5.52	4.94	5.64
L. b6	4.74	4.88	5.18	4.80	4.86
W. b6	5.48	5.56	6.14	5.48	5.74
Av. of six classes	5.31	5.48	5.80	5.26	5.49
Average efficiency, per cent	100.	103.2	109.2	99.06	103.4

The curves for auditory and visual memory differ chiefly in the smaller increase from 9 to 10 A. M. and the larger increase from 10 to 11 A. M. shown by the curve of visual memory. The superiority of 9.2 per cent which 11 A. M. shows over 9 A. M. is surprisingly large, overtopping by 2.5 per cent the differences in efficiency between the same periods shown in the case of memory for auditory digits.

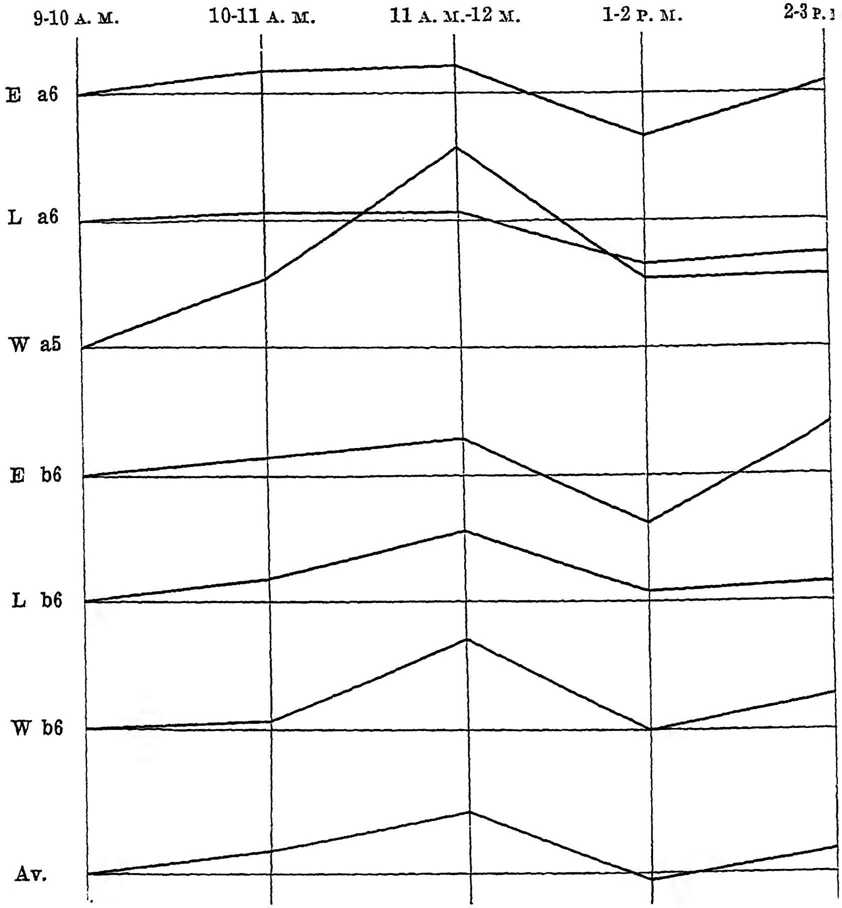

Fig. 5. Showing the diurnal course of efficiency in memory for visual digits.

For several reasons, the use of a series of digits in excess of the subjects' span is not an ideal test for the present purpose. Most pupils apparently are not seriously bothered by the fact that they are unable to reproduce the whole series; but many, as soon as the number of digits exceeds their memory-span, become confused and fail completely. Various methods used by different pupils and by the same pupil at different times, give their users certain advantages or disadvantages according to the

case. The results of certain pupils, for these and other reasons, show greatly varying scores in different tests of the series, and this may in part account for the noticeable lack of harmony in the details of the diurnal curves of efficiency for the groups.

5. *Tests in Recognition*

(1) *Material used.*—Series of ten nonsense-syllables of three letters each were constructed for the initial presentation, followed by the same ten syllables mixed indiscriminately with ten new syllables for the subsequent exposure. The syllables were constructed of black letters 2¾ inches in height, on white cards 3¾ by 7½ inches. The cards were fastened one above another on a strip of gray cloth, there being one column of ten in the case of the series first exposed and two columns of ten each in the case of the test series—the series exposed thereafter. The syllables used are given below:

Text 1 A.	2 A.	3 A.	4 A.	5 A.
kes	rol	jod	lem	mep
cag	kuf	zan	zat	vib
var	jer	bal	neb	lat
nub	pif	ker	hus	zed
rad	geb	ren	tid	kas
ber	mez	kep	reg	ren
guf	fex	luf	pof	fos
wap	mup	dar	lez	rul
dut	dak	sor	git	pex
fon	tib	tuk	mol	vul
1 B.	2 B.	3 B.	4 B.	5 B.
tud	zat	fet	fas	fek
nop	sim	cak	tal	cos
lor	lep	mel	sos	mip
cov	pex	raf	fep	vix
ros	tep	nog	gam	tam
ruv	len	tuf	con	kim
fip	nof	daf	rif	lud
jip	rus	ret	tur	mir
zib	min	tur	rud	zur
dul	nir	nus	lan	rus

Series A, gives the syllables which were studied.

Series B, gives the syllables which were mixed with those of A to form the test series.

(2) *Method of conducting the tests.*—Instructions were given as follows: "I am going to show you a series of nonsense syllables which will be exposed for a certain length of time. You are to study these syllables so that you can remember them; so that you would know them if you saw them again. After they are taken out of sight, another series of syllables will be shown you from which you are to pick out and write down all the syllables that you remember having seen in the first list. Don't put down any syllables which were not on the first list."

The first list was exposed at school "E" for one minute, but for forty seconds at the other schools, the latter time having been found to be sufficient. The second series was left in view at all schools for one minute, which was sufficient time for the subjects to complete their work.

(3) *Treatment of data and computation of results.*—The results were scored by simply counting the number of syllables which were correctly recognized, without regard to the order in which they were written down. No account was taken of mistaken recognitions; they were entirely disregarded.

(4) *Results.*—The average curve of efficiency in the recognition test is very similar to those found for memory of auditory and visual digits. A continuous increase is shown during the forenoon culminating in a maximum during the 11 o'clock hour, followed by a fall at 1 P. M. to the level of the first hour, with a

TABLE VI. RECOGNITION

SHOWING THE AVERAGE NUMBER OF SYLLABLES CORRECTLY RECOGNIZED

Class	9:12 A. M.	10:12 A. M.	11:12 A. M.	1:12 P. M.	2:12 P. M.
E. a6	7.38	7.72	8.02	7.60	7.86
L. a6	7.38	7.52	7.50	6.82	7.06
W. a5	7.48	7.46	7.60	7.28	7.52
	9:42 A. M.	10:42 A. M.	11:42 A. M.	1:42 P. M.	2:42 P. M.
E. b6	7.82	8.04	8.32	8.10	8.80
L. b6	6.84	7.88	7.14	6.76	6.98
W. b6	6.90	7.22	7.60	7.18	7.24
Av. of six classes	7.30	7.64	7.69	7.29	7.57
Average efficiency, per cent	100.	104.7	105.3	100.	103.7

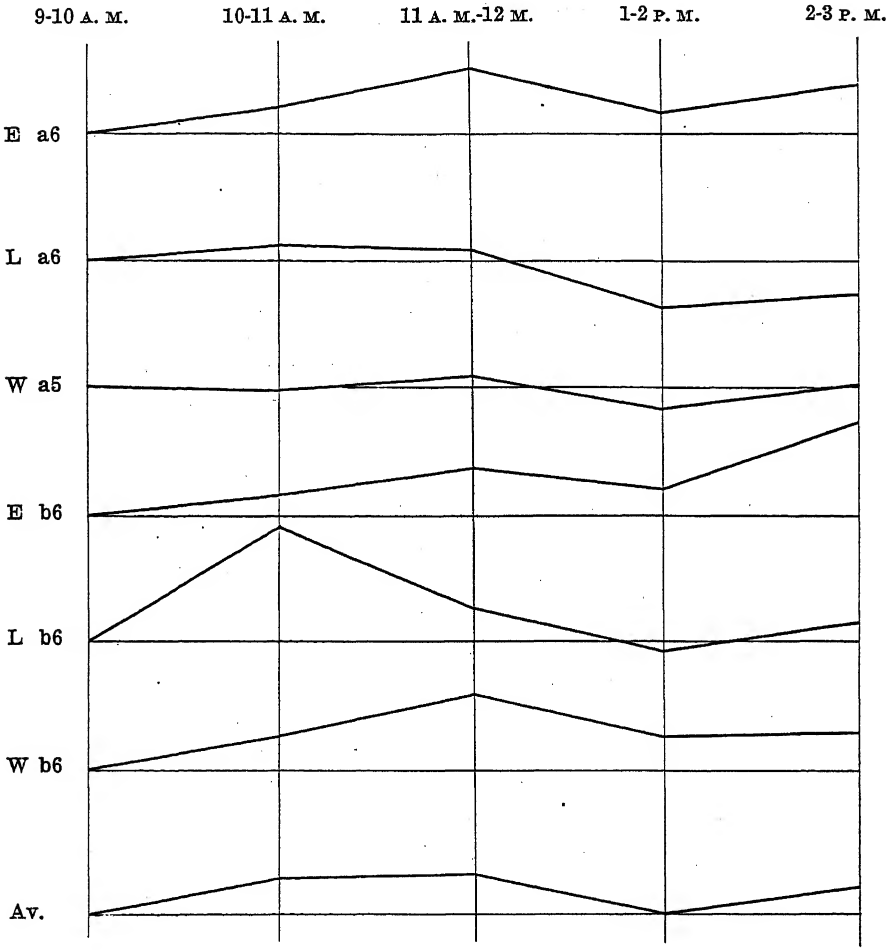

Fig. 6. Showing the diurnal course of efficiency in recognition of nonsense-syllables.

subsequent rise until the end of the school session. The curves shown by some of the individual classes vary considerably from the average course. The course of efficiency of class L. a6 differs radically from the average; the maximum occurs at 10 A. M. instead of at 11 A. M.; the minimum occurs at 1 P. M. instead of at 9 A. M., and the efficiency at 2 P. M. is still below that of the

first morning hour. W. a5 shows a slight decrease at 10 A. M. and a larger one at 1 P. M. L. b6 shows a high maximum at 10:42 A. M.; and at 1:42 P. M. efficiency is at its lowest. Despite these fluctuations, the general tendency is toward an increase in efficiency as the morning goes on, with a decrease following the lunch hour and a final upward movement in the latter part of the afternoon session.

The curves of efficiency in memory for auditory and visual digits and in recognition of nonsense syllables vary alike and are in all essentials the same as those found in the case of addition and multiplication. The course of efficiency in the memory functions, however, is less uniform, and a greater amount of difference between the groups is shown. It was found in the memory tests that large individual differences existed, and that the same individuals showed markedly different success at different times, largely because of the use of different methods. But that these factors are the cause of the noticeable lack of harmony in the results of the groups, is not evident.

The chief difficulty discovered in the use of the recognition test lies in the possibility of chance differences in the tests used. Occasionally the nonsense syllables, meaningless to the average person, are identical with slang words, or nick-names, etc., with which the pupils are familiar; and their recognition in such cases is, of course, an easy matter. The general method employed in these tests should in the long run result in the neutralization of the effects of such factors. Although the results are such that the main tendency stands out clearly, we should not on that account fail to recognize the possibility that occasional advantages from associations with the syllables used, might result in group fluctuations of greater or less manitude.

(5) *Comparative summary of the work of previous investigators.*—Unfortunately the number of investigations of the memory-function which bear on the question of the diurnal course of efficiency is very small; and of those which are at hand, the results are based on the work of so few subjects, in most cases, that the conclusions have a limited significance.

Larguier des Bancels,[58] using passages of prose, found the following number of seconds required to learn a passage: before coffee, 316 (av. of 16 days); before lunch, 349 (8 days); after lunch, 341 (7 days); before dinner, 345 (9 days); after dinner, 280 (5 days). These results are clearly not in harmony with the facts secured in the present work. However, this experimenter found that for reproduction of the passages, the after-dinner results were the best, and the morning results the worst. It is very likely that in the case of an adult habits of life enter very largely into the determination of the course of efficiency.

Schuyten[59] found on the whole a slight superiority of the forenoon over the afternoon. This difference, as Schuyten points out, is largely due to fluctuations in interest in the work; since he found that the subjects did by far the better work in the first trial, regardless of the time of day at which it took place.

Marsh[60] reports a clear variation in the case of a single subject who devoted twelve days to tests in memorizing ten German words and their meaning. The morning was the best period, the efficiency decreasing somewhat as the morning progressed. In the afternoon there was a minimum efficiency; this was followed by a slight plateau until 8 P. M., after which there is a decided decrease.

The same writer finds that memory for visual digits has its period of greatest efficiency early in the morning, as shown by the following summary of mistakes made:

7 A. M., 0.8; 10 A. M., 1.9; 1 P. M., 1.8; 7 P. M., 1.5; 10 P. M., 1.2.

This shows the course of efficiency of but one adult subject.

Four other subjects show a different course of efficiency. Following are the average results in mistakes made and percentage of error:

	7-9. A. M.		12-2 P. M.		5-7 P. M.		9-11 P. M.	
	Mis.	P. E.	Mis.	P. E.	Mis.	P. E.	Mis.	P. E.
Four subjects..	3.4	0.42	2.7	0.37	2.4	0.40	3.4	0.37

58 Larguier des Bancels, J., "Note sur les variations de la mémoire au cours de la journée", *L'Année psych.*, vol. 8 (1901), pp. 204–214.

59 Schuyten, M. C., "Sur les méthodes de mensuration de la fatigue chez les écoliers", *Archives de physiol.*, vol. 2 (1903), p. 321.

60 Marsh, H. D., *op. cit.*, p. 50.

The fact found here is that the midday and afternoon periods are by far the best.

In tests of memory for auditory digits with women students in the university, Marsh found the following results:

	Mistakes	P. E.
9 A. M.	9.0	0.7
12 M.	6.9	0.6
4 P. M.	7.0	0.5

In the group average (number of individuals not stated) the superiority of the midday period is pronounced; the morning is particularly bad; while the afternoon period is nearly the best period.

On the whole, the work of Marsh does little more than show the existence of wide individual differences. But in those cases where several subjects are grouped together, the results seem to be in harmony with those which have been found in the present work.

Winch[61] tested at two periods of the day the memory for visual percepts (twelve consonants arranged in three rows of four each) of 45 school-boys, thirteen years of age on the average. Practise in the tests was continued until the pupils' performance became "steady"; and then, of the two equal groups into which the class was divided, one was tested in the morning at 9:45-10:05 A. M., the other in the afternoon at 4:00-4:20 P. M. The data were scored by giving 3 marks for consonants correctly reproduced and placed; 2 if "one place" out of position; and 1 if "two places" out of position. The following results appear:

Time	9:45-10:05 A. M.	4-4:20 P. M.
Average score of four preliminary tests	240.9	240.9
Average of three final tests	266.7	253.0

The morning group show an efficiency superior by nearly six per cent to that of the afternoon workers. This is due largely

[61] Winch, W. H., "Mental Fatigue in Day-School Children as Measured by Immediate Memory", *Journ. Ed. Psych.*, vol. 3 (1912), Part I, pp. 18–29.

to the fact that those who work in the morning improve more rapidly than those who work in the afternoon. Winch states: "One of the pupils in the morning group and six in the afternoon group cease to improve, begin to oscilate in their work, and tend on the whole downward" (p. 27).

In the second study,[62] the same investigator working with 51 boys of another school, and using the same general methods as above, found the following results:

Time	9:45-10 A. M.	4-4:15 P. M.
Average score of four preliminary tests	157.8	157.8
Average of four final tests	164.2[62a]	161.1

The efficiency shown by the morning workers exceeds that of the afternoon workers by about two per cent. It was found also that eleven pupils of the afternoon group, as opposed to four of the morning group, showed either no improvement or else a loss of efficiency.

The results of Winch's excellent experiments cannot be directly compared to the results found in the present work, since in the former the afternoon tests were given at a much later hour. In the present work the curve of efficiency is not carried beyond 3 P. M., at which hour it is showing an upward tendency; and Winch finds that from 4 o'clock on efficiency is fairly low. If the results are viewed together, it would appear that the afternoon increase in efficiency shown by the present work is of very short duration followed by a decrease. But there is, of course, no certainty that such is the case.

On the whole, it must be said that previous work is in some instances in accord with the results of the present investigation, but in some cases not; while much of it is entirely neutral.

6. *Tests in Speed and Accuracy of Movement*

(1) *Material used.*—For speed, accuracy, and steadiness of movement, the "Maze" test, of Thorndike, has been used. A

[62] *Op. cit.*, Part II, pp. 75–81.

[62a] In the original article, a typographical error is undoubtedly responsible for the incorrect average (162.2) which appears there.

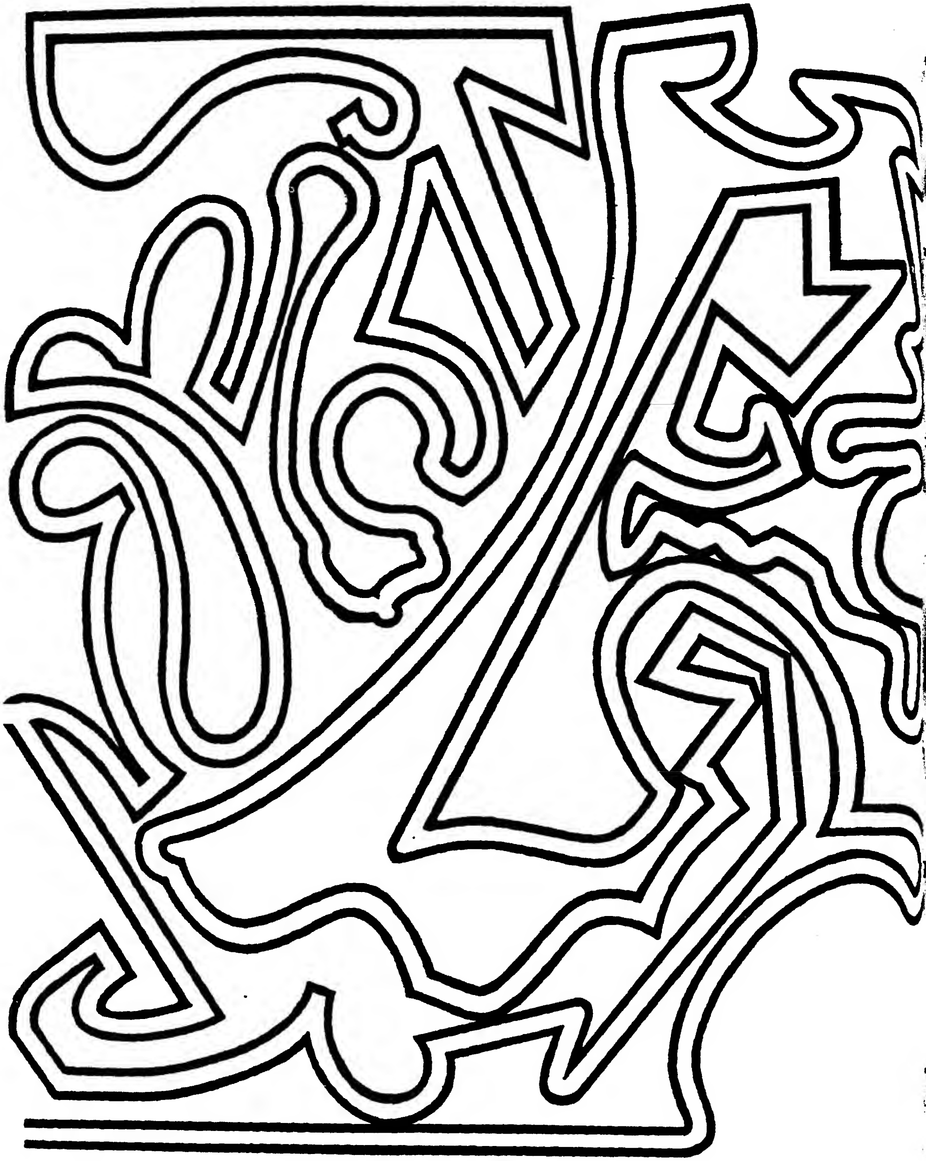

Fig. 7. The "Maze" Test.

test was sought which would give an indication of the diurnal course of efficiency of the various activities employed in ordinary school drawing. Since the "Maze" test measures the speed, accuracy and steadiness of movement—three factors largely involved in drawing—it should give a fair indication of efficiency in that form of school work. It will be seen by observing Figure 7 that the test requires the tracing of curves, angles, and lines of various sorts, running in nearly all possible directions, and on the whole should be a very fair test of motor speed and control.

The forms were printed on smooth paper, size 8½ by 11 inches.[63] Pencils of moderate hardness and average sharpness were used.

There is at least one rather serious objection to the use of this form of test for experiments of this kind. It lies in the fact that different individuals, and the same individuals at different times, employ different methods of working. Some attend chiefly to speed, covering more ground, but making more errors. Others attend chiefly to accuracy, and in consequence produce a small quantity but high quality of work. Others divide their attention between the two; and all intermediate degrees are found. The same individuals during the series of five tests sometimes change their method. A subject who had attended chiefly to accuracy, on finding at the completion of the test that others had covered a much greater distance, would on the next occasion speed up, and later either speed up still more or drop back to the original more careful method. Many of those who worked too fast in the beginning, producing too many errors, might go through a somewhat opposite course of changes.

Throughout the present investigation, an attempt was made continually to impress upon the subjects the importance of avoiding errors due to excessive speed and of reaching high

[63] The regulation size of paper for this test is much smaller (6 by 8 inches); the larger paper seems to be much better adapted to the work, for it can be held in position with greater ease, since both hands can be rested on the paper without frequent moves to prevent interference with the drawing.

accuracy. In this, entire success was not attained, and the work of many subjects had to be discarded on account of great changes in the method of attack.

(2) *Method of conducting the tests.*—The papers were laid face upward in front of the subjects; and the signatures, date, etc., were filled in before the beginning of the test. The following instructions were then given: "This is a test in drawing; we want to find out how quickly and how accurately you can draw. You are to draw a line, beginning at the place marked 'start here', right down the middle of the pathway between the two black lines. You must use the greatest care not to touch either of the black side-lines, to cut off corners, or to run out of the pathway in any way. You must try, of course, to draw as rapidly as possible, but above all try to keep from making errors. There are two other things to remember: First, you must draw directly along through the maze without removing your pencil from the paper; and, second, when you have arranged your paper in the way that you like best for drawing, you must leave it in that position throughout the test."

The pupils were then given a moment in which to arrange the paper to their liking. When once they had decided on the most favorable arrangement, it was insisted that the paper should not be moved during the test, and that the same position should be taken on the later days when the tests were made.

Everything being in readiness, the subjects placed their pencils at the starting point, and the word "go" was given. The time (75 seconds) was kept with a stop-watch.

(3) *Treatment of data and computation of results.*—The drawings were scored by the number of linear inches covered.

The number of errors were estimated after some preliminary experiments in which the touches were counted and different papers were compared. The papers were divided into five grades, grade 1 being of very high quality, grade 5 very poor, with three intermediate stages and grades. The estimation was made by observing the paper in general, and by paying particular attention to a selected small area.

An actual count of the number of errors would, of course, have been a very much more refined method, but with such a host of papers, the task would have been stupendous, and since the other method seemed to be quite satisfactory, the additional precision obtainable by actually counting would scarcely have been worth the additional time involved.

The final averages were computed in the same manner as in the previous tests.

(4) *Results*

a. Speed of movement.—Table VII shows the number of inches traced.

Plainly, the course of efficiency for speed of movement is of a different type from those found in the previous tests. The chief difference, and one that is very noticeable, lies in the fact that instead of there being a decrease in efficiency at the first afternoon hour, there is a very decided increase. This trait is shown with greater or less clearness by all the classes. Moreover, instead of finding the maximum efficiency to be at 11 A. M., as in the functions previously considered, it appears in this case at 2 P. M. All of the classes, with the single exception of W. b6, agree in this respect. With regard to the hour of minimum efficiency, there is a good deal of irregularity. On the average, it occurs at 9 A. M., and such is the case in three classes; while two others have their minimum at 11 A. M., and another at 10 A. M. The average curve shows, on the whole, a consistent but slight increase of efficiency during the morning, while the afternoon hours are decidedly superior.

The irregularity of the various curves of speed of movement is much more noticeable than with the other functions that have been considered. The first two classes, on the whole, closely follow the average curve. Class W. a5 differs by showing a drop of efficiency at 11 A. M., as compared with 10 A. M., and by showing another drop at 2 P. M. in comparison with 1 P. M. E. b6 shows an equally great departure from the average results by the fact that both 10 and 11 o'clock are periods of

less efficiency than the first morning hour. The increase that this class shows in the afternoon hours, too, is unusually great. L. b6, instead of showing a steadily increasing efficiency during the morning hours, shows exactly the reverse; 1 P. M. and 2 P. M. show equally great efficiency, which is exceedingly great in comparison with that of the morning. W. b6 also shows a decrease at 11 A. M. in a curve which otherwise closely follows the average.

TABLE VII. SPEED OF MOVEMENT

Showing the Average Number of Inches Traced in 75 Seconds at Different Hours of the School Day

Class	9:15 A. M.	10:15 A. M.	11:15 A. M.	1:15 P. M.	2:15 P. M.
E. a6	43.18	43.32	44.42	46.34	47.28
L. a6	31.06	31.24	34.46	35.34	37.60
W. a5	32.66	34.32	33.22	35.10	34.64
	9:45 A. M.	10:45 A. M.	11:45 A. M.	1:45 P. M.	2:45 P. M.
E. b6	43.38	41.42	42.26	45.14	49.12
L. b6	29.28	28.98	28.30	34.50	34.50
W. b6	32.32	33.32	31.20	34.42	34.76
Av. of six classes	35.31	35.43	35.64	38.47	39.65
Average efficiency, per cent	100.	100.34	100.93	108.9	112.2

The great irregularity of the curves of the individual classes makes it very difficult to discover with certainty the diurnal rhythm of speed of movement. One characteristic of the daily variation is clear, however, and in contrast with the curves found for the other mental functions: the greatest efficiency appears in the afternoon. The most striking feature of all is that the customary after-lunch drop in efficiency does not appear at all.

Speed of movement, in finding its most favorable time in the early afternoon hours, shows itself to be a function of markedly different character from the more purely mental activities. Apparently the factors which arise at the time of the midday meal and of the noon recess, do not produce an inhibiting effect upon this function, although their effect is very clear in the case of computation, memory, and recognition.

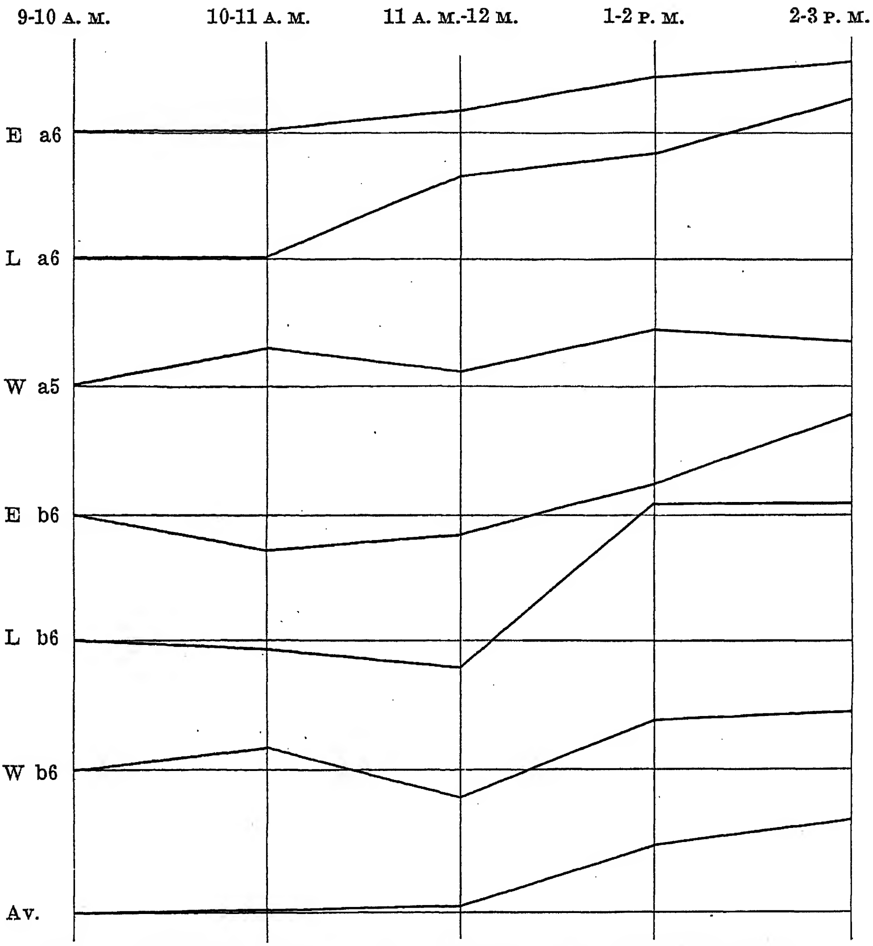

Fig. 8. Showing the diurnal course of efficiency in speed of movement involved in the "Maze" test.

Mention has been made of the difficulties in this test, which make it almost impossible to find an accurate measurement of either speed or accuracy independently. Changes of method are found in the work of many subjects; and it is clear that a pupil can trace twice as far on one occasion as on another, with the result, inevitably, of making a great many more errors. It is likely that much of the lack of harmony between the curves

of the several classes is due largely to shifts in the method of work. The curves of speed should on that account be viewed only in comparison with those for accuracy.

b. Accuracy of movement.—Grade 1 represents a very high grade of work, nearly free from errors; grade 2 represents fair accuracy, the number of errors numbering about ten; grade 3 work is medium, with from twenty to thirty errors; grade 4 is given for poor work with from thirty to forty errors; grade 5 represents very inaccurate work, the errors commonly numbering above fifty.

Table VIII shows the daily variations in accuracy of movement.

It is at once evident that accuracy pursued a different course from speed. In all but one of the classes, accuracy increases from the first to the last morning hour. The single exception, W. a5, shows a superiority at 11 A. M. over 10 A. M., but both hours are inferior to 9 A. M. In every case, however, the two afternoon hours show less accuracy than the two later forenoon hours, and in four of the six classes the minimum efficiency is found in the afternoon. The average curve shows 2 P. M. to be poorest, 1 P. M. next, followed by 9 A. M. and 10 A. M. with the maximum efficiency at 11 A. M.

c. Accuracy and speed combined.—To get a clearer idea of the situation, we should compare the ebb and flow of accuracy with those of speed in the same classes. It is apparent that in most cases where a high point in the efficiency for one is found, there is a low point in the efficiency of the other element.[66] Compare for example, the curves for speed and accuracy of class L. b6, which shows for either function a very ragged course. The average percentile efficiency of this class in each function is given below for the sake of comparison.

	9 A. M.	10 A. M.	11 A. M.	1: P. M.	2 P. M.
Speed in percentages........	100.	98.8	96.7	117.9	117.9
Accuracy in percentages	100.	102.3	104.2	85.1	91.5

[66] It will be found in a later section, that among individuals a very high negative correlation (—.76) between speed and accuracy exists.

TABLE VIII. ACCURACY OF MOVEMENT

SHOWING THE AVERAGE GRADES OF ACCURACY AT DIFFERENT HOURS OF THE SCHOOL DAY[64]

	9:15 A. M.	10:15 A. M.	11:15 A. M.	1:15 P. M.	2:15 P. M.
E. a6	2.056	1.985	1.928	2.028	2.03
L. a6	2.033	1.9	1.932	1.966	2.10
W. a5	1.635	1.7	1.666	1.666	1.635
	9:45 A. M.	10:45 A. M.	11:45 A. M.	1:45 P. M.	2:45 P. M.
E. b6	2.165	1.856	1.835	2.0	2.232
L. b6	1.566	1.53	1.5	1.8	1.7
W. b6	1.876	1.732	1.7	1.77	1.77
Av. of six classes	1.838	1.784	1.761	1.871	1.911
Average efficiency, per cent	100.	102.9	104.2	98.2	96.0

In the face of such facts, we are loath to draw a conclusion with regard to either speed or accuracy, for it is evident that in most cases the increase in one factor is only apparent and is gained at the expense of the other. And since, in the form in which the results are stated above, the varying degrees of efficiency in the two elements are not directly and with certainty comparable, the diurnal course of *real* efficiency is obscure in either case.

Nearly all classes agree, however, in showing speed to be greater and accuracy less, in the afternoon. That is to say, the afternoon seems to call forth a different method from the one usually employed in the morning. Most individuals "speed up" in the afternoon, but are less careful with regard to errors, while in the morning the opposite method is used.

It would be very unsatisfactory to leave the results of this test without at least an attempt to show the course of the two factors combined. In an effort to accomplish this, the mathematical treatment described below was applied to the figures. The method is arbitrary and crude, but it probably does justice to all the groups. The method employed is based upon the observation that on the average, for a "grade 1" paper the amount traced was about 25 inches; about 40 inches for a

64 The smaller number represents the greater accuracy.

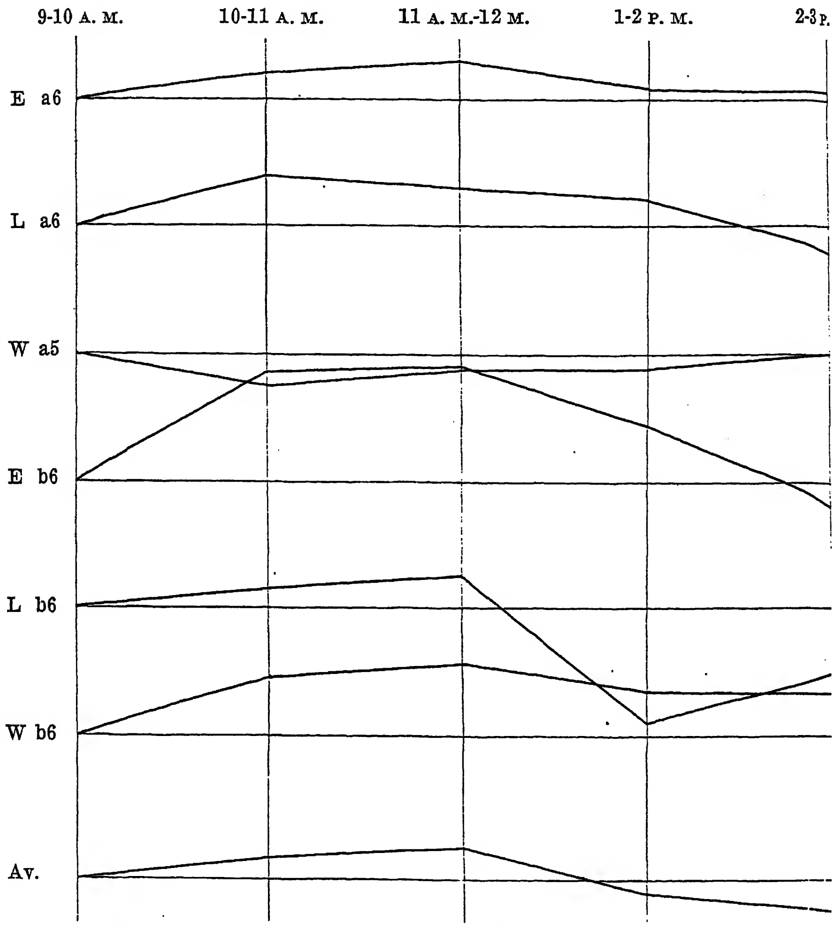

Fig. 9. Showing the diurnal course of accuracy of movement.[65]

grade 2 paper, and so on by steps of 15 inches for each succeeding lower grade. The difference then between papers graded 1 and 2, between those graded 2 and 3, etc., is about 15 inches. Hence the formula:

Compensated speed equals actual speed at that hour minus 15, multiplied by grade at 9 A. M., minus grade at the given

[65] In order to have the elevation of the curve mean increased accuracy, the plot is the reverse of the figures in Table VIII.

hour. "Compensated speed" means speed and accuracy combined, or, to be more exact, a speed minus a penalty for inaccuracy.

The course of accuracy and speed, thus arbitrarily combined, shows a progressive increase during the day. There are, indeed, several ragged departures from the average curve in the case of several individual groups, but this is no more than could be expected when the various difficulties and possible sources of error in the mathematical treatment are considered. The variations from hour to hour during the day are surprisingly large, but one cannot rely on the figures for anything more than a rough indication of the facts.

Although the maximum efficiency occurs at 2 P. M. in every case, the curve, compared with those for the various mental functions thus far considered, is consistently very high at 1 P. M. The striking differences, then, which the curve for speed alone showed, when compared with the curves for computation, memory and recognition, are still evident in the course of efficiency after discounts have been made for inaccuracies.

(5) *Comparison with other investigations.—a. Speed and accuracy of movement*

Dresslar,[67] in experiments upon himself with the tapping test extending over sixteen days, found a distinct diurnal rhythm.

Time of day	8 A. M.	10 A. M.	12 M.	2. P. M.	4 P. M.	6 P. M.
Number of seconds to make 300 taps	37.8	35.4	34.6	35.5	33.5	35.1

The minimum appears in the early morning, the maximum at 4 P. M. The best period of the forenoon is the 12 M. hour. Dresslar remarks: "The shape of this curve was unexpected, for it was naturally thought that the greatest rapidity would be attained sometime during the forenoon" (p. 520), showing

[67] Dresslar, F. B., "Some influences which affect the Rapidity of Voluntary Movements", *Amer. Journ. Psych.*, vol. 4 (1892), pp. 514-527.

that—since he was experimenting on himself—the actual course of efficiency did not follow the subjective feelings. Dresslar found also that muscular work (walking, etc.) decreases, and

TABLE IX. SPEED AND ACCURACY OF MOVEMENT

Showing the Average Number of Inches Traced at Different Hours of the School Day After Discounts Have Been Made for Differences in Accuracy

Class	9:15 A. M.	10:15 A. M.	11:15 A. M.	1:15 P. M.	2:15 P. M.
E. a6	43.18	44.38	46.24	46.76	47.67
L. a6	31.06	33.23	35.97	36.33	36.61
W. a5	32.66	33.35	32.76	34.54	34.64
	9:45 A. M.	10:45 A. M.	11:45 A. M.	1:45 P. M.	2:45 P. M.
E. b6	43.38	46.05	47.21	47.61	48.13
L. b6	29.28	29.17	29.29	30.89	32.49
W. b6	32.32	35.48	34.62	36.01	36.35
Av. of six classes	35.32	36.94	37.68	38.69	39.31
Average efficiency, per cent	100.	104.6	106.7	109.5	111.2

mental work increases, the rapidity of tapping. The curve of efficiency found by Dresslar corresponds rather closely to those of the present work, differing in that the former shows less efficiency following the noon meal. This drop may be due, as Dresslar suggests, to the fact that the subject habitually relaxed from the time of lunch until 1:30 P. M.

Bergström[68] found the rate of movement, expressed in number of strokes per minute, to vary as follows:

	7 A. M.	8 A. M.	10 A. M.	12 M.	2 P. M.	4 P. M.	6 P. M.
Subject A	262	272	278	267	277	270	269
Subject B	260	......	268	268	......	......	......

The first subject shows an increase in efficiency during the forenoon and the efficiency at 2 P. M. is about equal to the maximum. The second subject shows an increasing efficiency during the morning. These results are largely in harmony with those of the present work.

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68 Bergström, J. A., "A Study of Mental Activity", *Amer. Journ. Psych.*, vol. 6 (1894), pp. 247-274.

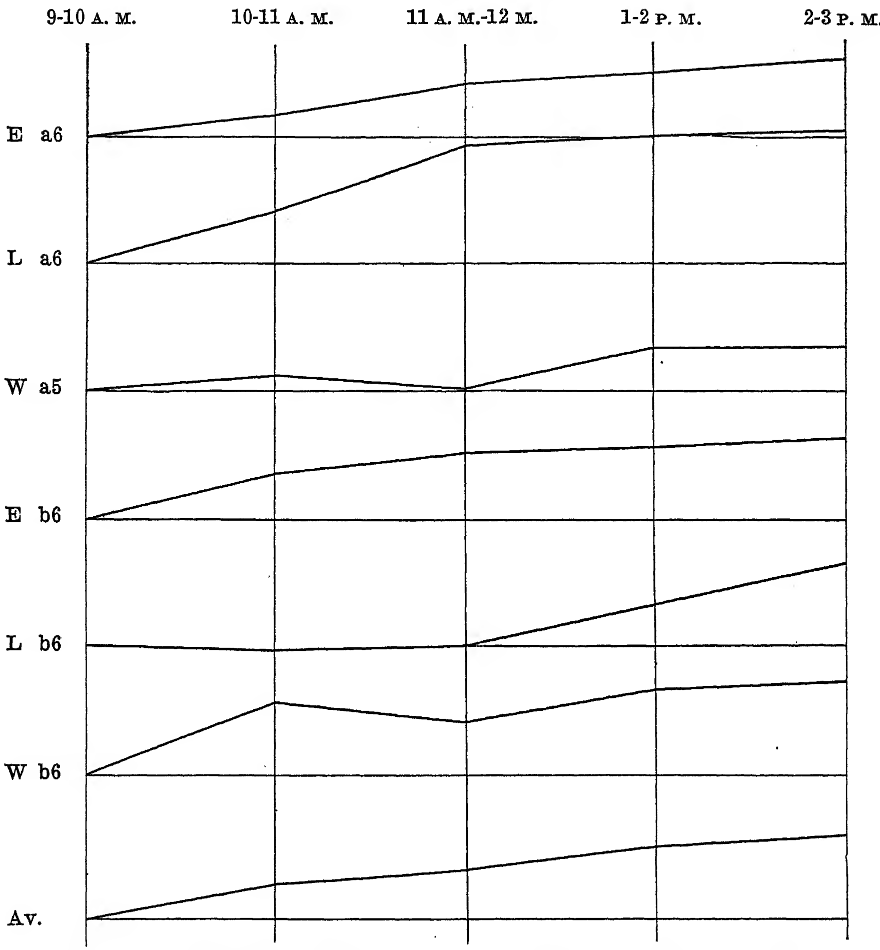

Fig. 10. Showing the diurnal course of speed and accuracy of movement.

Marsh[69] found that accuracy in different forms of tests reaches a maximum in the late forenoon, while speed in the tapping test in his own case reached a maximum in the evening, when accuracy was at its lowest. This he explains by the assumption of a greater amount of neural excitability in the

[69] Marsh, *op. cit.*, p. 17.

evening, which would accelerate speed but interfere with accuracy of movement.

Tests by the same writer with three subjects, in striking 200 small squares with a pencil point, resulted as follows:

Three Subjects, 2400 Squares

7-9 A. M.				12-2 P. M.			
Time	P. E.	Misses	P. E.	Time	P. E.	Misses	P. E.
47.7	0.75	6.0	1.12	44.3	0.46	7.1	1.15
4-6 P. M.				9-11 P. M.			
Time	P. E.	Misses	P. E.	Time	P. E.	Misses	P. E.
44.8	0.56	5.6	1.01	47.1	0.71	5.1	0.68

The maximum efficiency is from noon to 2 P. M., with a minimum in the morning. Accuracy pursues the opposite course. These results are in agreement with those of the present article.

In tests of writing the words "one" to "twelve" Marsh found similar results, as shown by the following:

7–9 A. M.		12–2 P. M.		4–6 P. M.		9–11 P. M.	
Time	P. E.	Time	P. E.	Time	P. E.	Time	P. E.
81.	0.5	77.	0.6	78.	0.5	80.	0.4

Other tests with the so-called "hold-and-let-go" test gave the same variations (p. 19). Other observations by Marsh on the speed of magazine wire-stitchers, of making paper coin-cases and of numbering bills and ledgers in factories, although very discordant and involving many factors which tend to distort the normal course, show a tendency to greater efficiency in the late forenoon hours and minimum ability at the extremes of the day.

Marsh's tabulations of data for speed and accuracy gathered by the Departments of Psychometry and Anthropometry at the St. Louis Exposition, seem to indicate an afternoon superiority (p. 20). About 66 per cent of the groups tested at various times show a superiority in the afternoon. These results are of doubtful value, however, because of the possibility of large individual differences in ability of people working at the different periods.

Hollingworth,[70] in tapping tests (400 taps) upon three groups of five subjects each, given daily for ten days, found the following results, which are given here in percentages based on the efficiency shown at the initial hour:

	7:45 A. M.	10 A. M.	12 M.	3:10 P. M.	5:30 P. M.
Av. 5 men	100.	100.3	99.5	99.8	99.6
Av. 5 women	100.	101.8	99.5	101.5	102.1
Av. 5 men (irr.)	100.	104.	103.4	103.3	104.7

Considerable irregularity in the results is shown, but in every case 10 A. M. is superior to 7:45 A. M.; the work following the noon hour is about equal to, or slightly better than, the first period; while the afternoon shows an increase in efficiency.

Intensive experiments with the same test show similar results:

	10:30 A. M.	11:15 A. M.	12 M.	1:30 P. M.	2:15 P. M.	3:00 P. M.
Average time	49.8	49.2	47.8	47.7	48.0	48.3
P. E.	.9	1.1	1.2	1.3	1.3	1.4
Efficiency, per cent	100.	101.6	104.4	104.6	104.0	103.4

A constant increase in efficiency takes place during the day. These results are in harmony with those we have obtained from the children, and persist in spite of the fatigue we should expect to develop in Hollingworth's work.

In tests on co-ordination of movement, 100 strokes on the three-hole target, Hollingworth found in the extensive tests "increasing efficiency up to midday, then a falling off from this maximum."

In a test of steadiness, in which the subject held a small rod, at arm's length, in a hole of a diameter slightly less than twice that of the rod, the same investigator found in the two-day continuous work experiment, results as follow: Efficiency at 10:30 A. M., 100; at 11:15 A. M., 100; at 12 M., 103; at 1:30 P. M., 120; at 2:15 P. M., 106; and at 3 P. M., 106. Steadiness apparently increases throughout the day, notwithstanding the effects of fatigue.

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[70] Hollingworth, H. L., "Variations in Efficiency During the Working Day", *Psychol. Review*, vol. 21 (1914), pp. 473-491.

One subject, a woman of 38 years, whose experience in typewriting had carried her beyond the practice stage, worked under Hollingworth's directions. In almost continuous work for two days the following times were required to complete a given amount of typing:

	A. M.		P. M.					
	10	11	1	2	3	4	5	6
Time	61.0	58.1	57.7	56.8	55.6	55.6	56.3	59.4
Errors	134.	101.	115.	113.	86.	79.	86.	102.

Speed and accuracy increase consistently during the day to a maximum in the late afternoon, from which time efficiency begins to decrease. These results are in harmony with those obtained in the present work, except that Hollingworth found no indication that exceptionally high speed is at the expense of accuracy.

b. More complex motor activities

Marsh,[71] by means of questionaires to many physical directors, trainers, and athletes, found that in the opinion of most such men, the afternoon is far superior to the forenoon for complex motor activities.

Bogardus,[72] in an interesting experiment of controlled muscular activity, has shown that continued work results in muscular inaccuracy which increases irregularly and at a rate dependent upon the speed of the activity and on the relative difficulty of a given piece of work for the individual. Gross figures show that about twice as many inaccuracies occur in the last half as in the first half of a given piece of work. Bogardus supports his experimental results by statistics gathered from records of accidents in several European countries and in America which show, on the whole, a larger number of accidents in the latter half of the forenoon and afternoon. It seems probable, however, that the statistics are complicated by in-

[71] *Op. cit.*, p. 32.

[72] Bogardus, E. S., *The Relation of Fatigue to Industrial Accidents* (1911), p. 69.

numerable factors, and that the effect of fatigue is of minor import. For instance, the number of street-car accidents or accidents from other methods of traffic in a retail district would be greater during the hours of maximum traffic.

Bogardus' experiments and statistics show that fatigue from continued muscular activity is important; and throw light on the present problem by the probability that the fatigue in some forms of work will more than balance the opposing force of the diurnal course of efficiency.

c. *Voluntary muscular power*

Some excellent research has been upon the problem of the diurnal variations in voluntary muscular power; and since the subject is cognate with the one under discussion, it may be well briefly to summarize the results of the various investigations at this point.

Lombard,[73] in extensive experiments with the Mosso ergograph as modified by himself, found the maximum voluntary muscular power to be between 10 and 11 A. M. and 10 and 11 P. M. The minimum occurs between 3 and 4 A. M. and 3 and 4 P. M. An afternoon rise occurs at 2 P. M., followed by a fall in power between 3 and 4 P. M.

Patrici[74] using the Mosso ergograph upon himself and one other subject at various periods during the day and night, found the period at 2:30 P. M. the best; the evening period superior to the morning; and the latter period about equal to the midnight period. He concluded that this course was coincident with that of bodily temperature.

Harley,[75] in ergographic tests extending over six days, found the following average results in terms of kilogram-meters:

	A. M.			M.	P. M.							
Hour	9	10	11	12	1	2	3	4	5	6	7	8
K-M	6.2	6.4	8.7	7.0	9.5	8.2	9.9	7.8	8.9	8.7	7.2	8.8

[73] Lombard, W. P., "Some Influences Affecting the Power of Voluntary Muscular Contractions", *Journ. Physiol.*, vol. 13 (1892), pp. 5-71.

[74] Patrici, *Archives italiennes de biologie*, vol. 17 (1892), p. 134.

[75] Harley, V., "Effects of Sugar and Smoking on Muscular Work", *Journ. Physiol.*, vol. 17 (1894), p. 97.

A steady rise until 11 A. M. is evident, with a maximum at 3 P. M. It is noticeable, also, that muscular power is very great at 1 P. M.

Kraepelin[76] found a daily variation characterized by a gradually increasing efficiency during three or four hours after each meal. The immediate effects of a meal, according to this investigator, are to decrease one's muscular ability as a result of the increased demand of the digestive processes on the blood supply.

Roemer[77] reached conclusions which are essentially in accord with those of Kraepelin.

Christopher[78] employed 90-second ergograph tests on 1127 Chicago school children at each hour of the school day, followed by fuller tests with four boys and four girls. His results show a maximum at 9 A. M. with a slight decrease until 11:30 A. M., where a heavy drop in strength occurs. The curve ascends rapidly from 12:30, is fairly high at 1 P. M., increasing to the highest point in the afternoon at 2:30 P. M., whence it descends until 4 P. M. Christopher's general conclusions are: (1) There is a much greater drop in efficiency during the morning period than in the afternoon. (2) Strength is not so great in the afternoon as in the morning, but is better sustained.

Storey,[79] in extended experiments with a large group of individuals tested by ergograph and dynamometer both for voluntary and electric contraction, found the following results:

(1) There is a morning period of increasing strength, culminating at 10 A. M., 11 A. M. or 12 M., followed by a fall in power until 1 or 2 P. M.; an increase until 3 or 4 P. M.; an evening rise until 6, 7 or 8 P. M.; with a final fall in the later hours.

(2) All individuals followed the same general course of

[76] Kraepelin, E., "Zur Hygiene der Arbeit", *Zeitschrift für Psychiatrie*, vol. 25 (1896), p. 593.

[77] According to Weygandt, W. Kraepelin's *Psychologische Arbeiten*, vol. 2 (1899), p. 697.

[78] Christopher, W. S., "Report on Child Study Investigation", reprint from *Ann. Rep. of Bd. of Ed. of Chicago* (1898-9), pp. 1-48.

[79] Storey, T., (*a*) "Some Daily Variations in Height, Weight and Strength", *Amer. Phys. Educ. Rev.*, vol. 6 (1901). (*b*) "Daily Variation in the Power of Voluntary Muscular Contraction", *ibid.*, vol. 7 (1902). (*c*) *Studies in Voluntary Muscular Contraction* (1904).

efficiency, although there were some individual differences and the same individuals differed somewhat in different series of tests.

(3) The results for voluntary contractions were the same as for contractions produced by electric stimulation.

Unfortunately the tables given by Storey show only the "number of comparisons showing gain" from one hour to another, and do not give a quantitative comparison of the actual amounts of work done at different times.

Marsh,[80] using Cattell's 1903 type of spring ergometer, tested one subject and found the maximum efficiency to be in the period from 3:30 to 4:30 P. M., as compared with 8 to 9 A. M. and 10:30 to 11:30 P. M. The same investigator found, in tests with five subjects using the hand dynamometer and the hand-foot dynamometer, that strength takes the following course: a minimum in the morning; a fairly rapid rise until 11 or 11:30 A. M.; a level or slight decline until 12:30–2 P. M.; an increase to a maximum at 5 P. M. ($\mp$ 1 hour); thence a continuous fall. In general form this curve is like those found by a majority of the investigators preceding Marsh.

(6) *Summary of results.*—With regard to speed of movement it was found that a progressive increase in efficiency took place during the day, the height of the curve in the afternoon being particularly noticeable. Accuracy took very nearly the opposite course, especially in the afternoon hours. When speed and accuracy in the same function was arbitrarily combined, the curve showed an upward tendency through the day with the maximum occurring at the last hour. This curve differed in two ways from those of the more purely mental functions previously considered; in the maximum at 2 P. M., and the efficiency at the hour following the midday meal. Previous work in tests of speed and accuracy for simple and complex movements seems to be generally, but not invariably, in harmony with these results.

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[80] *Op cit.*, p. 24.

COMPLETION TEST. NUMBER 1

Where the Dandelions Went

Wh.... Willy ...... two .... old, he lived .... a red farm-h........ with .. yard .... front .... The dandelions were .... thick th......; so that ...... yard lo........ yellow instead of gr......

One bright ...... Willy's ma.... put on ...... straw hat ...... sent him into ...... yard to .... She knew ...... yard had .. high ....; and .... could not o...... ...... gate; so .... safe. W...... it ...... time ...... him .... take .. nap and she went .... c...... him, she noticed that .. great many of the dand........... .... go.... She won.......... where they ....; but, as ....ld not talk much, ... did not ...... him .... them.

A short .... after, while .... was .... his crib, his mamma went .... draw .... wat.... When ...... buck.... came .... full ...., the top was all y.......... with da................ Look...... down into ...... well, ... could ...... no .... at all, only dandelions.

.... wonder, then, where ...... blos........ had .... Willy ...... been .... busy try...... .... fill ....

The course of efficiency for muscular contractions, voluntary and involuntary, differs from that of speed and accuracy of movement, as well as those of the more purely mental functions. It agrees with the former in showing an afternoon maximum, and with the latter in showing some degree of inefficiency following the noon meal.

7. *Completion Test*

(1) *Material used.*—A test was sought which would demand of the subjects something more than a mere retentive capacity or facile association; something more complex; something creative, if possible. The *"Completion Tests"*, such as those originally employed by Ebbinghaus, seemed to be the nearest

COMPLETION TEST. NUMBER 2

THE KING AND THE LITTLE GIRL

A king ....ceived in great sta.... in .. village. The school children and th....... teach.... wel.......... him, and .. lit...... g...... recited .... to him. with wh...... he was .... mu.... ple......... "You .... performed .... task nicely," .... king. "But now .. wish .... ask ...... some qu.............." he said and sh.............. child .... orange. To .... kingdom does .... orange be........?"

The ch...... a.............. shy.... that ...... orange be............ to the veg............ .... "W........ does .... belong?" .... ag...... poin................ gold-piece. ".... ...... min.................dom" .... answer. "But ...., do I then be.........my child?" ...... the third .... The .... the king pleas.......... and said: "To .... heav......" Then a tear .... in .... of the k...... and .... lif....... ...... gi.... up and kis..............

approach to the tests desired.[81] The two tests used by Terman[82] and one arranged by Whipple[83] were also thought to be suitable.

However, the requirements of the present work made it impossible to employ them in their original form.

Number 1, of the texts above, is a modification of the text

[81] Ebbinghaus, H., "Ueber eine neue Methode zur Prüfung geistiger Fähigkeiten und ihre Anwendung bei Schulkindern", *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, vol. 13 (1897), pp. 401–459.

[82] Terman, L. M., "Genius and Stupidity", *Pedagogical Seminary*, vol. 13 (1906), pp. 307–373, especially pp. 342–7; also Terman and Childs, "A Tentative Revision and Extension of the Binet-Simon Measuring Scale of Intelligence", *Journ. Ed. Psych.*, vol. 3 (1912), pp. 198–202.

[83] Whipple, G. M., *Manual of Physical and Mental Tests* (1910), especially pp. 445–458.

COMPLETION TEST. NUMBER 3

THE PEASANT'S HONESTY

In one .... the Eur.......... wars .... officer was once .... to search ...... fodder ...... the horses. He rode for a .... time in a lon...... val...... and ...... no one, but at .... caught si...... of a mis............ hut. When he knocked at ...... do.... an old man .... out. "Show .... a field, old man," .... off........, "where .... men can .... fodder for .... hor........

The peasant went on .... them and .... ab...... a quar........... .... hour. they .... to .. fine bar...... field. "This is .... we ...... search...... for," said ...... o............. "Not yet," ans.......... .... pe........... and we.......... They fol................ and .... last to an.......... bar..................

After ...... sol................ mowed the gr...... and loaded it .... hor...... and we.... ab........... ride .... of.......... sa..... "Y.............. led .... farther th.... was nec.................... fi...... field ...... bet...... than ...." "I .... it," .... peasant, "...... it ...... not ...."

arranged by Whipple; Number 5, of one arranged by Terman; and the other three were arranged by the writer. The difficulty of the texts increases somewhat in the latter part, this arrangement being made chiefly for a certain few pupils who might otherwise complete the whole test before the expiration of the time-limit.[84]

The tests, while hardly fulfilling the intention of a test of creative literary ability, demand a mental activity of a complex sort, and ability to synthesize the fragmentary parts into a

[84] At first glance it may appear that the texts which are more difficult in the last part would be a source of considerable error in the results. Most of the pupils, however, did not reach the more difficult section; and since those who did worked at each and every hour of the day, their relative efficiency at the different hours would be shown without distorting the results.

COMPLETION TEST. NUMBER 4

THE FOX AND THE LION

There ...... once .. fox .... had nev...: seen .. lion; and so wh.... he .... for ...... fir.... time, he w.... so frightened th......... did not kn.... wh.... to do. ...... lion ...... him no harm, and the ...... crept ...... and ran to ...... hole and ...... th...... He stay.... .... it un...... he had .... search ...... food, and .... crept ...... in .... fear.

But the fox once .... met .... some days .... th..... This .... fox ...... not quite so ....ly frigh.......... He look.... the great k...... of ...... beasts .... face; and ins........ of ....ping aw.... .... fright as be..................... off slow...., and ev.... sto........ and .... round.

A third .... the fox ...... th.. l...... and went dir.............. to ...... as .... noth...... .... all to .... He .... say "Good morning, Mr. Lion, ... you do .... fine ......?"

whole. It was found upon inquiry in one class, that the students who did the best work in the completion test were, according to the opinion of the teacher, about the best of the class in composition-work. So the course of efficiency found with the use of this test, may be considered, roughly at least, similar to the diurnal rhythm for the mental activities demanded by composition-work.[85]

The texts, reproductions of which are shown here, were printed in 10-point type on sheets 8½ by 11 inches, with ½-inch spaces between lines.

[85] Several students were found who were practically unable to do anything with this test. Foreigners, particularly Chinese and Japanese, although ranking high in school work as well as in the other tests, were as a rule quite helpless in the completion test. The work of such subjects was not considered.

COMPLETION TEST. NUMBER 5

THE STRENGTH OF THE EAGLE

One .... eagle went with the .... birds .... see .... could fly the highest. They agreed .... he who .... fly ...... hi.......... should be called the strongest .... All started .... same .... and .... away among ...... cl......... One by ...... they gr.... tired and re............. but .... eagle .... upward and .... until .... was .. me.... speck .... heavens. When he .... back ...... others were wait...... for .... and when .... touched ...... gr........... linnet flew .... ba.... where .... had .... hiding and .... that he ...... the st.............. bird. "I .... stronger th........... e........," he said, "for not .... did I .... high, but .... eagle .... down, I left .... hid................. and .... up a little ...." The ot...... birds .... a council to .... matter. After .. long .... decided .... eagle .... stronger .... not only ...... he ...... as high but .... the l.......... as well.

(2) *Method of conducting the tests.*—The papers were placed face down in front of the pupils and the following instructions were given: "On these sheets are printed a story in which many of the words or parts of words have been left out and in their places are series of dots. The length of the series of dots is roughly to show the length of the word that has been omitted. When the signal is given, turn over the papers and fill in the blanks so as to complete the story. Don't put down any words which do not 'make sense'. If you get stuck on a word, do not waste too much time with it, but go on to the next."

At the signal "ready", the subjects seized the paper, and at "go" it was turned over and the work started. Two and

a half minutes were allowed for the test. This test was always given seventh in the series of eight.

As a rule the pupils enjoyed this test, and applied themselves to the utmost, although a great many complained of its difficulty. It was very evident that there was a great difference in the difficulty of the different texts used. Text 3, for instance, was much more difficult for the children than Text 1. Under the general method of experimentation used in this work, however, such differences would be compensated in the results.

(3) *Treatment of data and computation of results.*—The papers were scored by simply counting the number of elisions correctly filled. No discounts were made for omissions; elisions filled in such a manner as not to make sense were considered the same as omissions. The results show the amount of accurate work, or work of good quality, done at the different hours.

The weight of the different squads was equalized by obtaining the final average from the averages of the squads, as previously described.

TABLE X. COMPLETION

SHOWING THE AVERAGE NUMBER OF ELISIONS CORRECTLY SUPPLIED AT DIFFERENT HOURS OF THE SCHOOL DAY

	9:19 A.M.	10:19 A.M.	11:19 A.M.	1:19 P.M.	2:19 P.M.
E. a6	22.36	23.80	24.60	24.08	25.18
L. a6	21.20	22.24	23.80	21.50	22.70
W. a5	20.28	20.12	21.42	21.28	21.48
	9:49 A.M.	10:49 A.M.	11:49 A.M.	1:49 P.M.	2:49 P.M.
E. b6	21.64	22.24	22.70	22.06	22.38
L. b6	18.64	21.16	21.40	21.12	21.34
W. b6	19.18	19.88	21.46	20.88	21.10
Av. of six classes	20.55	21.57	22.56	21.82	22.36
Av. efficiency, per cent	100.0	105.0	109.7	106.2	108.8

(4) *Results.*—The ebb and flow of efficiency in the completion test is well defined and is essentially the same as that found for the arithmetical and memory tests. The curve runs upward from a morning minimum to a midday maximum, fall-

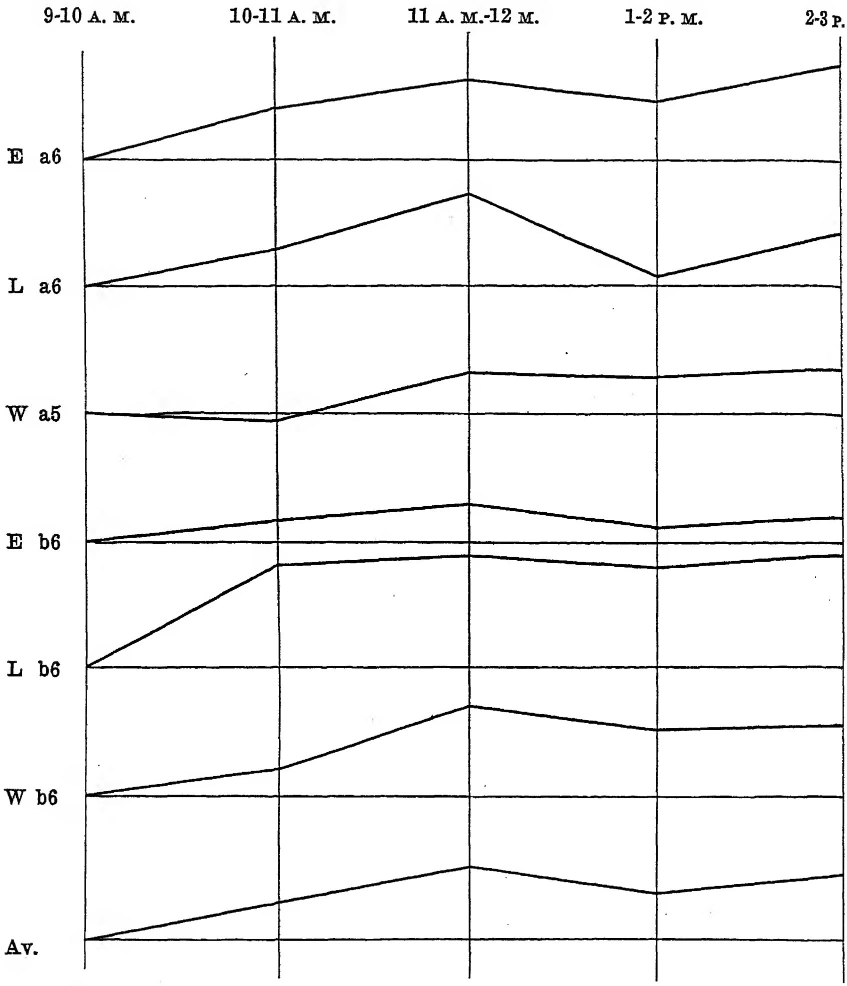

Fig. 11. Showing the diurnal course of efficiency of the mental processes involved in the completion test.

ing again after the lunch hour, and increasing again during the last hour of the school day. No very striking differences are found among the individual curves, although the percentile variations from hour to hour in many classes are very large. The relative efficiency of all the hours compared to that at 9

A. M. in the case of L. b6, is very great. In the case of W. a5, the pupils were working in very bad form at 10 A. M., where there is a minimum efficiency. In other tests as well (addition, multiplication and recognition), this class gave indications of being relatively inefficient at this time.

The average difference of efficiency between the maximum and minimum is very great 9 per cent; and the superiority in many cases of the other hours over the hour of least efficiency is great. These large fluctuations are mainly due to certain classes, such as L. b6, in which there is a heavy depression at 9 A. M., but very small differences between the other hours.

Thus it appears that the mental functions involved in the completion test, although they are correlated only to a small extent with the other forms of test that have been used, follow nearly the same course of efficiency.

(5) *Summary of work of other investigators.* As far as the writer is aware the completion test has not been previously employed in the problem of the diurnal course of efficiency, although it has been used by Ebbinghaus[56] and Wiersma[57] in investigations of the effect of fatigue. The work of the latter does not give results which can be compared here, but Ebbinghaus found that the effects of five hours' work failed, in the case of children fourteen to sixteen years of age, to show a decrease in the quantity or quality of work, although with younger children (nine to eleven years) a small lessening of efficiency was noted.

Some work has been done, with questionaires chiefly, and with information gained from biographies, in finding the preferred hours of work of authors, writers and students. A reference to some of the results may be of interest here.

Bergström[58] reports that Heerwagen found that students, in answer to questionaires, showed the following preferences: 182

[56] Ebbinghaus, H., *op. cit.*

[57] Wiersma, E., "Die Ebbinghaus'sche Combinationsmethode", *Zeitschrift fur Psychologie und Physiologie der Sinnesorgane*, vol. 30 (1902), pp. 196-222.

[58] Bergström, J. A., "A Study of Mental Activity", *Amer. Journ. Psych.*, vol. 6 (1894), pp. 247-274.

preferred the morning; 133 the evening; 6 the afternoon; while 28 found study easy at all times. The same writer reports that Professor Barnes found among Cornell students that 66 preferred the morning, 6 the afternoon and 39 the evening.

O'Shea[89] by means of questionaires obtained data from which he summarizes as follows: "Practically all those who reported testified that their minds worked best in the forenoon, 18 reported being best in the afternoon, while 2 found that they could accomplish more at five o'clock in the morning than at any other hour. The best hours ranged from 7 to 12 in the forenoon, while the choicest period of the day is from 9 to 11."

Marsh[90] tabulated information which he obtained from biographical sketches of authors and writers with the following results: The morning was preferred by 34 per cent; afternoon, 1 per cent; night, 12 per cent; after midnight, 6 per cent; morning and afternoon, 17 per cent; morning and night, 4 per cent; afternoon and night, 3 per cent; whole day, 23 per cent.

On the whole the indications of these several groups of statistics are in harmony with the results we have found with the completion test, although there is no detailed corroboration. To attach much weight to the results obtained concerning the preferred hours of work of authors and students would, however, involve several assumptions which cannot well be made. One must assume that the hours during which a particular individual worked were really his preferred hours, a thing which, in the case of biographies especially, is not always clear. Economic conditions and habits of life may often determine the distribution of the working hours. One must assume further that the preferred hours are actually the most efficient hours, a probability which very often is not the fact.[91]

8. *Cancellation Test*

(1) *Material used.*—For a test which would give an indi-

[89] O'Shea, M. V., "Aspects of Mental Economy", *Bull. Univ. Wis.*, vol. 2 (1901), p. 195.

[90] Marsh, *op. cit.*, pp. 59-69.

[91] See Dresslar's statement quoted on p. 71.

cation of the alertness of attention, its working under distracting influences, and the rate of perception, the so-called "Number Checking Test", proposed by Woodworth and Wells, was selected.[92]

The form of this test is shown herewith. It consists of twenty lines of fifty numerals each, printed in 8-point type with a margin of one and one-eighth inches at the top and bottom, and of one and three-eighth inches on the sides. The lines are so arranged that each contains the symbols 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, five times and each successive fifth of the line contains each of the ten symbols once. By preventing two identical symbols from coming in succession at the end of these series of ten, the occurrence of "runs" of several symbols was prevented. The second half of the text is made by reversing the arrangement of the first half, the equality between halves being established by this means.

The test consists in striking out the 0's with a single stroke of a pencil. The symbol 0 was chosen in preference to the others because it is one of average difficulty and presents less striking features than such symbols as 1 or 7, and yet has been found to be less difficult for checking than 6, 9 or 5.[93] The same symbol was employed throughout the series of experiments.

It should be added that this test involves factors aside from the concentration and steadiness of atttention. Motor activities are largely concerned, and a measure is obtained of the speed and accuracy of reaction to a particular stimulus. Similar tests have been termed "discrimination tests", since they require the discrimination, or the picking-out and recognition, of one stimulus from several possessing similar features. The wandering or lessening of attention, it is said, will result in a lessening of the speed of discrimination of the desired from the undesired stimuli, and will result in a reduction of the

92 For a description and extended discussion of this test, see Woodworth, R. S., and Wells, F. L., "Association Tests", *Psych. Monograph*, vol. 13 (1911), pp. 24-29.

93 Woodworth and Wells, *op. cit.*, p. 27.

5 1 6 8 4 9 2 3 7 0 1 2 7 5 0 4 8 6 9 3 4 1 8 9 0 2 5 6 3 7 1 7 5 6 0 8 9 2 4 3 7 8 6 9 0 4 3 1 2 5
7 8 0 5 1 3 4 2 6 9 2 4 0 9 7 6 1 5 3 8 3 2 0 4 1 5 7 9 6 8 4 8 1 2 6 7 3 9 0 5 3 7 9 0 8 6 5 2 1 4
3 5 9 7 8 4 6 1 0 2 5 1 8 2 3 7 4 9 6 0 8 5 9 3 2 4 1 0 7 6 9 3 4 5 2 0 8 6 1 7 9 3 1 6 7 5 8 4 0 2
2 7 3 9 6 5 0 8 1 4 9 7 3 6 1 5 0 2 8 4 0 4 7 8 5 9 6 2 1 3 0 9 3 1 5 6 4 8 7 2 4 2 3 5 6 7 9 0 8 1
4 2 5 3 0 1 7 9 8 6 3 8 6 0 9 1 5 4 7 2 9 3 6 7 4 8 0 1 2 5 6 4 9 3 1 2 0 7 5 8 6 1 2 7 4 9 0 5 3 8
9 4 7 0 3 8 5 6 2 1 6 0 9 3 8 2 7 1 4 5 7 8 1 0 9 6 4 3 5 2 5 2 7 9 4 1 6 3 8 0 1 0 4 8 2 3 7 9 5 6
0 9 8 2 5 6 1 7 4 3 8 3 5 4 6 9 2 0 1 7 6 0 2 1 3 7 9 5 8 4 2 1 8 4 9 5 7 0 3 6 0 9 5 2 1 8 6 7 4 3
1 0 4 6 2 7 9 5 3 8 0 6 2 8 4 3 9 7 5 1 2 7 4 5 6 0 3 8 9 1 3 5 0 7 8 4 2 1 6 9 5 6 8 1 9 2 4 3 7 0
8 6 1 4 9 2 3 0 5 7 4 5 1 7 2 8 6 3 0 9 1 9 5 6 8 3 2 7 4 0 8 6 2 0 7 3 5 4 9 1 2 4 7 3 5 0 1 8 6 9
6 3 2 1 7 0 8 4 9 5 7 9 4 1 5 0 3 8 2 6 5 6 3 2 7 1 8 4 0 9 7 0 6 8 3 9 1 5 2 4 8 5 0 4 3 1 2 6 9 7
7 9 6 2 1 3 4 0 5 8 4 2 5 1 9 3 8 6 0 7 9 0 4 8 1 7 2 3 6 5 6 2 8 3 0 5 1 4 9 7 5 9 4 8 0 7 1 2 3 6
9 6 8 1 0 5 3 7 4 2 1 9 4 5 3 7 0 2 6 8 0 4 7 2 3 8 6 5 9 1 9 0 3 6 8 2 7 1 5 4 7 5 0 3 2 9 4 1 6 8
0 7 3 4 2 9 1 8 6 5 9 6 1 2 4 8 7 0 5 3 1 9 8 3 0 6 5 4 7 2 1 5 7 9 3 4 8 2 6 0 8 3 5 9 7 2 6 4 0 1
3 4 7 6 8 1 2 5 9 0 6 3 0 7 5 9 4 8 1 2 4 8 5 9 7 3 1 2 0 6 7 1 0 2 9 6 4 5 3 8 3 4 7 1 6 5 2 8 9 0
6 5 9 7 3 2 8 4 0 1 0 8 3 6 1 4 9 7 2 5 2 5 3 4 6 9 0 1 8 7 5 4 1 7 2 8 3 9 0 6 1 2 6 5 8 3 0 7 4 9
8 3 5 0 9 4 7 2 1 6 8 5 7 0 2 1 3 9 4 6 5 2 1 0 8 4 7 6 3 9 2 7 4 5 1 9 0 6 8 3 6 8 9 7 1 0 3 5 2 4
1 8 0 9 7 6 5 3 2 4 2 7 8 4 6 5 1 3 9 0 3 1 2 6 9 5 8 7 4 0 4 8 2 0 5 1 6 3 7 9 4 1 8 0 5 6 9 3 7 2
2 0 4 8 5 7 6 1 3 9 7 1 6 8 0 2 5 4 3 9 6 7 0 1 4 2 3 9 5 8 0 6 9 4 7 3 2 8 1 5 2 0 1 6 4 8 7 9 5 3
4 1 2 5 6 8 0 9 7 3 5 0 9 3 7 6 2 1 8 4 8 6 9 7 5 1 4 0 2 3 8 3 5 1 6 7 9 0 4 2 9 6 2 4 3 1 5 0 8 7
5 2 1 3 4 0 9 6 8 7 3 4 2 9 8 0 6 5 7 1 7 3 6 5 2 0 9 8 1 4 3 9 6 8 4 0 5 7 2 1 0 7 3 2 9 4 8 6 1 5

Fig. 12. The Cancellation Test.

speed of reaction as well as in an increase of erroneous reactions. It is, however, clear that the speed attained in the test cannot exceed that of the muscular reaction of the subject. Lack of muscular adaptation, as well as the wandering of attention or any break in the effective mental attitude, results in inferior speed and accuracy.

(2) *Method of conducting the tests.*—The pupils were given the following instructions: "You will be given a paper on which are printed several rows of numbers. When the signal is given, you are to check out as fast as you can all of the 0's or zeros. Be careful not to overlook a single one." After the method of working was illustrated with the use of a sample series of symbols written on the blackboard, the papers were passed out face downward before the pupils. At the warning signal "ready" the subjects seized the corner of the paper and at the word "go" it was turned over quickly, and the cancellation started. A one-minute period was allowed for the test. The cancellation test was always the last of the series of eight tests; in nearly all groups it proved to be the favorite.

(3) *Treatment of data and computation of results.*—Correction of a large number of papers showed that the number of mistakes was very small; consequently in the final results no account has been taken of them. The grade of the papers represents the total number of 0's correctly cancelled.

The final tabulation of averages was done in the manner employed with the previous tests.

(4) *Results.*—A glance at the table and figure shows that the course of efficiency for cancellation is more closely akin to that found for speed and accuracy of movement than for those found in the various more purely mental processes. The tables of correlation (p. 113) show that although the correlation between cancellation and speed of movement in the maze test is not high (+ 0.29), it is the highest correlation which the cancellation shows. The same table shows moreover that the correlation of speed of movement with cancellation (+ 0.29) is the highest shown by speed of movement, being greater than the correlation

TABLE XI. CANCELLATION

Showing the Average Number of Digits Cancelled in One Minute at Different Hours of the School Day

	9:24 A.M.	10:24 A.M.	11:24 A.M.	1:24 P.M.	2:24 P.M.
E. a6	44.	43.94	44.32	44.08	45.54
L. a6	36.46	37.36	39.	38.14	39.46
W. a5	38.38	39.18	40.06	40.26	39.82
	9:54 A.M.	10:54 A.M.	11:54 A.M.	1:54 P.M.	2:54 P.M.
E. b6	42.54	42.76	44.6	45.56	44.02
L. b6	40.14	40.32	41.46	42.16	41.82
W. b6	37.14	37.44	37.74	37.96	39.02
Av. of six classes	39.44	40.16	41.19	41.36	41.61
Av. efficiency, per cent	100.	101.8	104.4	104.9	105.5

of speed with multiplication (+ 0.03), addition (+ 0.01), completion (+ 0.11) or memory (av. — 0.04).

Evidently, then, speed in the cancellation test is largely dependent upon the motor processes, and follows the diurnal course of efficiency of speed of movement. The rather low absolute amount of the correlation shows, however, that the addition of purely mental processes makes the aggregate a quite different activity from that involved in the maze test. Table XI shows that although the course of efficiency in cancellation follows that of speed of movement, it does so hesitatingly and with several exceptions (E. a6 at 1 P. M., L. a6 at 1 P. M., W. a5 at 2 P. M., and E. b6 at 2 P. M.) It will be noticed also that the average superiority at the 2 o'clock period over the 9 o'clock, in the case of speed in the drawing test, is more than twice as great (11.3 per cent, compared to 5.5 per cent) as the difference between the same hours in the cancellation test.

(5) *Comparison with the results of other investigators.*—Lobsien,[94] in experiments upon attention, in which the number of times a pupil raised his eyes in five minutes from an assigned reading was noted, found that the attention of school children

[94] Lobsien, M., "Schwankungen der psychischen Kapacität", *Pädag. Psych.*, vol. 5 (1902), pp. 1-110.

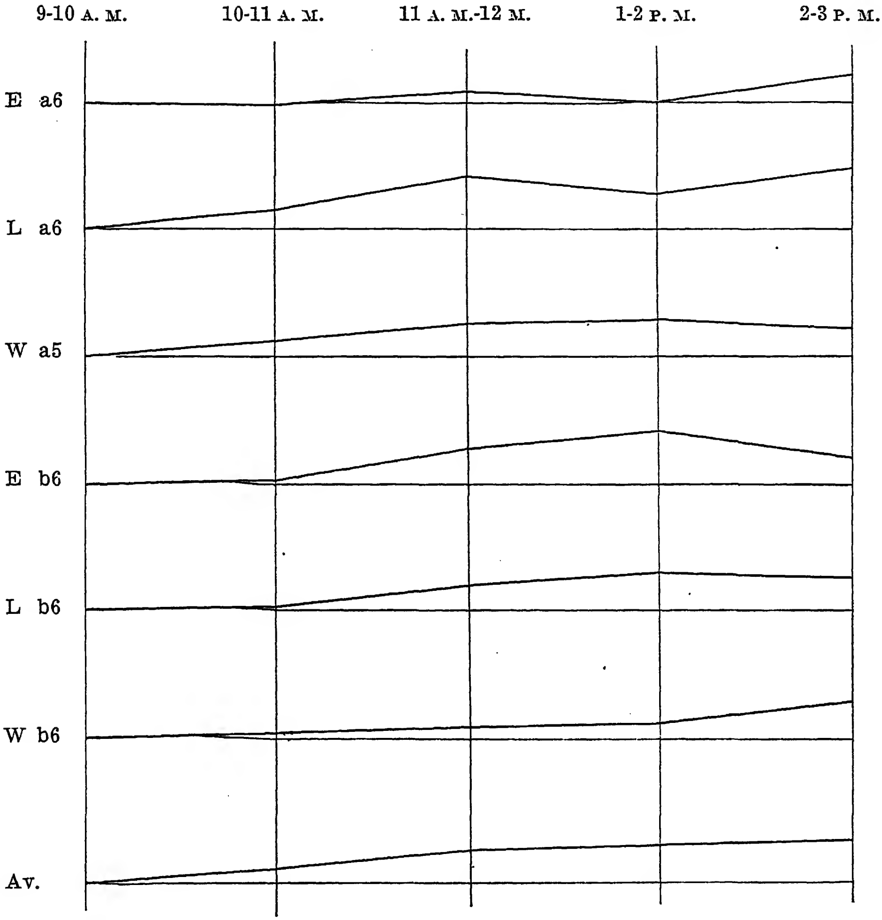

Fig. 13. Showing the diurnal course of efficiency in cancellation.

was greater in the morning in the months of October, November, December, January and February, but greater in the afternoon during the months of April, May, June and July;[95] while in March no difference was noted.

Pillsbury,[96] in experiments upon the least perceptible dif-

[95] August and September not tested.

[96] Pillsbury, W. B., "Attention Waves and Fatigue", *Amer. Journ. Psych.*, vol. 14 (1903), p. 314.

ference in shades of gray, with three subjects, at morning, noon, afternoon, and night, found the following results, given in the form of average attention span:

Morn.	Noon	Afternoon	Night
9.3	8.7	8.6	8.3

Attention apparently decreases steadily during the day. Many objections, however, might be raised to the application of these results to the problem of the diurnal course of efficiency. (1) The tests seem to be upon the senses employed, rather than upon attention; fatigue of the sense organs is probably largely responsible for the decrease of efficiency. (2) The subjects used are too few. (3) The periods at which the tests were given are too indefinite; for instance, tests at different hours within the afternoon period might give very different general results.

It is evident that the results obtained by these investigators of attention, except those of Lobsien for the winter months, are not in harmony with the curves we have found in the cancellation test.

Marsh,[97] however, in experiments with four subjects in simple and controlled reactions with the Hipp chronoscope, found a slight superiority for 12:30 P. M. and 5 P. M. over 9 A. M. These results do not carry much weight on account of the limited number of subjects. Experiments by the same writer, upon four subjects, in naming colors, show a maximum efficiency from 12 to 2 P. M., a somewhat less efficiency from 4 to 6 P. M., still less from 9 to 11 A. M., with the minimum from 7 to 9 A. M. Five men subjects, in tests of controlled associations (opposites), gave the following results expressed in time, percentage of errors, and mistakes:

No. of	7–9 A. M.			12–2 P. M.			4–6 P. M.			9–11 P. M.		
Words	Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.	Time	P. E.	Mis.
100	59.8	2.14	0.6	53.5	1.67	0.7	53.6	1.94	0.6	55.5	1.92	0.5

These results, and those from the color-naming experiments, are completely in accord with the results we have obtained in the cancellation test.

[97] *Op. cit.*, p. 46.

Marsh, in experiments with the familiar "A" cancellation test found the following:[99]

	Days	7-9 A. M. Time	P. E.	Mis.	12-2 P. M. Time	P. E.	Mis.	5-7 P. M. Time	P. E.	Mis.
Av. 6 Subjs. Canc. 1 Letter	12	55.7	0.80	1.0	51.6	0.62	1.4	53.5	0.88	1.4
1 Sub. Canc. 1-4 Letters	10	99.2	1.05	4.0	92.4	1.16	4.4	93.1	1.11	5.2

The maximum is from 12 to 2 P. M. with the minimum in the morning. These figures are essentially the same, for the periods tested, as were found in the present work. We must not, however, forget Marsh's caution that his results may be partly due to the fact that his subjects frequently were forced to work under artificial light at the extremes of the day.

In a final experiment with the cancellation of *e*'s and *a*'s from a book, Marsh found, with a single subject, for 15 days, a curve similar to the above.

7 A. M. Av. Time	P. E.	Omis.	10 A. M. Time	P. E.	Omis.	12-1 P. M. Time	P. E.	Omis.	4- P. M. Time	P. E.	Omis.
28.0	0.36	0.55	26.4	0.35	0.67	26.1	0.30	0.84	26.2	0.26	0.80

Hollingworth[100], in experiments in naming 100 colors, in which ten subjects worked twelve hours steadily on each of two days, found the following course of efficiency:

	10:30 A. M.	11:15 A. M.	12 M.	1:30 P. M.	2:15 P. M.	3:00 P. M.	3:45 P. M.
Av. Time	52.1	52.9	51.8	52.9	53.5	52.7	53.8
P. E.	1.6	1.7	1.6	1.4	1.7	1.8	1.8
P'c'tage of efficiency	100.	98.	100.	98.	97.	99.	97.

It is clear that these results are not in harmony with those obtained by Marsh or those of the present work. To the writer it appears that the decrease in efficiency which is shown to result from continued work under strict test conditions, is due to fatigue, which apparently develops rapidly and on that account masks the diurnal wave of efficiency.

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[99] For a description and criticism of this form of cancellation test see Whipple, *Manual of Physical and Mental Tests* (1914) Part I, pp. 305-329.

[100] Hollingworth, "Variations in Efficiency During the Working Day", *Psych. Rev.*, vol. 21 (1914), pp. 473-491.

The same writer, in tests of discriminative reaction, with the right hand to red, and the left hand to blue, using a similar method of experimentation, found that fatigue developed sufficiently to cause an increase in time of reactions, as shown by the figures below:

	10:30 A. M.	11:15 A. M.	12 M.	1:30 P. M.	2:15 P. M.	3:00 P. M.	3:45 P. M.
Time (in sigmas)	328	331	338	331	339	338	342
P. E.	6.4	7.2	7.4	7.4	8.4	7.2	7.4
P'c'tage of efficiency	100.	99.	97.	99.	97.	97.	96.

On the whole, there is but little uniformity in the results obtained by different experiments with regard to attentive and discriminative functions. The subjects, tests, and general methods used by the various researches, however, are probably responsible for the lack of harmony. Those obtained by Marsh agree with those of the writer; while Hollingworth's figures, which, however, show the effects of fatigue rather than the course of efficiency imposed by the day, contradict them.

9. *General Summary of the Results for Different Functions*

At this point only a brief summary of the foregoing results will be presented, reserving a greater part of the discussion for a later time when the facts that will appear in the succeeding sections can more readily be brought to bear.

Figure 14 shows the average curves for the various functions placed in series. It is evident that the curves fall into two groups, within which the resemblances are much greater than the differences. In the first group should be placed addition, multiplication, auditory and visual memory, recognition and completion. In all of these is found a more or less steady rise in efficiency from 9 A. M. to noon, followed by a decrease of differing but always noticeable extent at 1 P. M. and a subsequent rise during the last hour.

In the second group, which shows a curve with features quite distinct from the one just described, should be placed speed and

accuracy of movement and the processes involved in the cancellation test. The average curves of this group are similar to those of the former group, in showing a rise in efficiency during the forenoon; but are markedly different in showing a superiority at 1 P. M. over the morning, and in showing the last hour of the school day to be that of greatest efficiency.

The functions within each group are of a similar nature, but those of one group differ in kind from those of the other. In the first group, whose curve of efficiency is characterized by the 11 o'clock maximum and the decrease at 1 P. M., are found the functions of a more purely mental type. In the second group, which shows an almost continual increase during the day, are found the functions which are pronouncedly motor. Within the latter group, the curve of the more purely motor function, speed of movement differs more from the curves of the mental functions than does the curve of the cancellation test, which in addition to its motor elements is partly dependent upon the effectiveness of certain mental activities such as attention, discrimination and perception.

VII

Correlation of the Tests

From the data used in the preceding sections the correlations between the various tests have been computed. The work of students who did not complete all of the tests for the full period of five days was left out of consideration, together with all the work which for various reasons enumerated above (pp. 28 ff.) was thought to be untrustworthy.

The sum of the scores made by a subject in each of the five trials of each test was employed in determining his rank in that test.

The results of each class were divided according to sex, for the reason that sex differences, if there were such, would give the appearance of a correlation in the results where none would be found when the sexes were taken separately. Moreover,

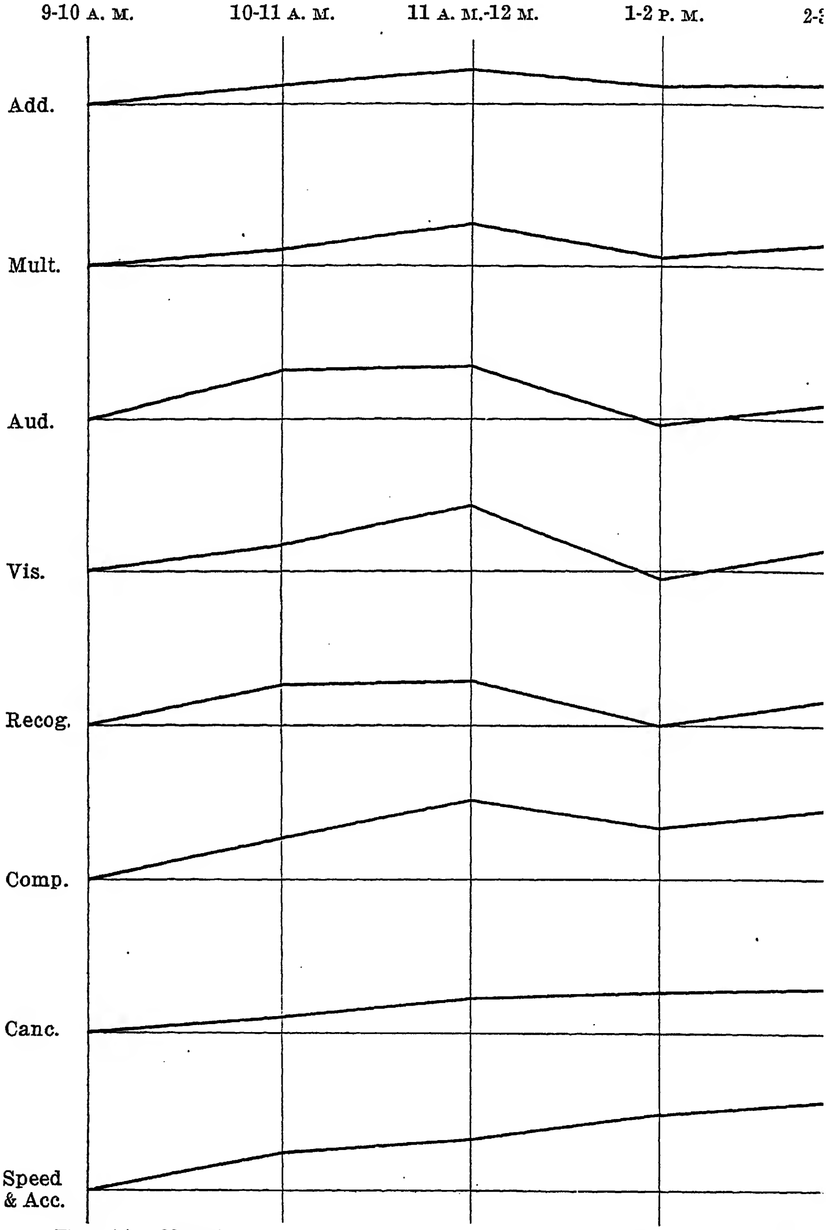

Fig. 14. Showing the average curves of efficiency during the day for all of the functions previously considered[100].

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[100] The curve of speed of movement is that obtained by discounting for inaccuracy. (See pp. 71 ff.)

separation of the sexes would show us definitely what sex differences, if any, exist.

For computing the coefficients of correlation, the familiar formula which is adapted to rank-differences was used.[101]

$$r = 1 - \frac{6 \Sigma D^2}{n(n^2 - 1)}.$$

1. *Correlations Shown by Different Groups*

The first series of tables (XII to XXIII) show the correlations for each of the separate groups, both the correlation of one test with each of the others and also the average of the correlations of a single test with each of the others. The correlations vary decidedly from group to group, as may be seen from comparison of the tables.

Table XII. E. a6. 11 Girls

In this class we find that multiplication correlates positively although in some cases the coefficient is nearly zero—with all the tests, save speed of movement. The highest correlation (+.49) is with addition; cancellation (+.48) is next in order; with completion (+.42) following. There is but little correlation between memory or recognition and either of these forms of computation. Speed and accuracy of movement are strongly correlated negatively (−.74). It is probable that this is largely due to the choice of working method by the subjects—a matter which has been referred to before. Some subjects work fast and make many errors, while others draw with extreme care and make fewer errors but cover relatively small distances.

Aside from those mentioned, the only other high correlation found in this group is that between visual and auditory memory, which is +.86. The coefficient in the case of visual memory

[101] For an analysis of this formula see Thorndike, E. L., *Mental and Social Measurements* (Ed. 2; New York, 1912), p. 168, or Whipple, G. M., *Manual of Physical and Mental Tests* (1914), vol. I, p. 41.

and recognition is + .49; auditory memory and recognition, + .45.

From the average correlation of one with all the other tests, it is seen that recognition has the highest coefficient (+ .235), with multiplication second (+ .202); accuracy shows a negative correlation. In no case is the correlation of one with *all* the other tests high enough to have much significance.

TABLE XII

E. A6. Fourteen Girls

	Mult.	Add.	Speed	Acc.[102]	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.49	—.24	+.31	+.42	+.48	+.12	+.01	+.03
Add.	+.49		+.02	+.03	+.17	+.44	—.16	—.05	+.04
Speed	—.24	+.02		—.74	+.16	—.08	—.20	—.18	+.12
Acc.	+.31	+.03	—.74		+.04	—.08	+.25	+.35	+.08
Compl.	+.42	+.17	+.16	+.04		+.42	—.12	—.18	+.30
Canc.	+.48	+.44	—.08	—.08	+.42		.00	—.26	+.37
Aud.	+.12	—.16	—.20	+.25	—.12	.00		+.86	+.45
Vis.	+.01	—.05	—.18	+.35	—.18	—.26	+.86		+.49
Recog.	+.03	+.04	+.12	+.08	+.30	+.37	+.45	+.49	
All Tests	+.202	+.122	—.132	+.03	+.15	+.161	+.15	+.13	+.235

[102] In the scores for accuracy the smaller number represents the higher quality of work; consequently the subject with the smallest number ranked no. 1, and so on down.

Table XIII. E. a6. 15 Boys

The correlation of multiplication and addition (+ .64) is greater than among the girls of the same class, and a very marked difference is shown by the negative correlation between auditory and visual memory (—.14). It will be noted that among the boys the computation tests correlate positively with speed and negatively with accuracy, which is exactly the opposite of what is shown in the girls' group. The boys' group agrees with the girls' group in showing but small correlations of one with all the tests.

TABLE XIII

E. a6. Fifteen Boys

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.64	+.15	—.14	+.35	+.26	+.21	—.34	+.17
Add.	+.64		+.09	+.05	+.03	+.59	+.30	—.34	+.33
Speed	+.15	+.09		—.86	+.54	+.47	—.45	.00	+.37
Acc.	—.14	+.05	—.86		—.18	—.32	+.49	+.08	—.11
Compl.	+.35	+.03	+.54	—.18		+.19	—.18	—.05	+.47
Canc.	+.26	+.59	+.47	—.32	+.19		—.10	—.13	+.56
Aud.	+.21	+.30	—.45	+.49	—.18	—.10		—.14	+.20
Vis.	—.34	—.34	.00	+.08	—.05	—.13	—.14		+.02
Recog.	+.17	+.33	+.37	—.11	+.47	+.56	+.20	+.02	
All Tests	+.162	+.21	+.04	—.123	+.146	+.19	+.041	—.11	+.25

Table XIV. L. a6. 10 Girls

The correlations here are in most respects similar to those found in the girls' group of class E a6. Addition and multiplication are strongly correlated (+ .74); auditory and visual memory show a correlation of + .40; speed and accuracy are negatively correlated (— .71), and there is no correlation between arithmetic and memory, except one negative coefficient (— .80) between addition and visual memory.

No test shows a significant correlation with all other tests, the coefficient + .142 of auditory memory and of + .138 of multiplication being the highest.

TABLE XIV

L. a6. Ten Girls

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.74	—.46	+.37	+.44	—.58	+.05	+.05	+.50
Add.	+.74		—.57	+.42	+.06	—.26	+.07	—.80	+.66
Speed	—.46	—.57		—.71	+.01	+.39	+.05	+.32	—.15
Acc.	+.37	+.42	—.71		—.20	.00	+.15	—.03	+.15
Compl.	+.44	+.06	+.01	—.20		—.12	+.05	+.27	—.32
Canc.	—.58	—.26	+.39	.00	—.12		+.30	—.09	—.05
Aud.	+.05	+.07	+.05	+.15	+.05	+.30		+.40	+.07
Vis.	+.05	—.80	+.32	—.03	+.27	—.09	+.40		+.09
Recog.	+.50	+.66	—.15	+.15	—.32	—.05	+.07	+.09	
All Tests	+.138	+.04	—.14	+.187	+.024	—.051	+.142	+.026	+.12

Table XV. L. a6. 17 Boys

There is still a fair correlation between the two forms of arithmetical work (+ .68), and a higher one for the two memory tests (+ .88). It is noticeable that although the correlation between the members of these two related pairs is very high, the correlation between a member of one with a member of the opposite pair is negative in every case. Computations correlate negatively with accuracy of movement, and have no correlation with speed. The completion test correlates strongly only with the cancellation test, and shows a fair correlation with all others (+ .24). The visual memory shows a correlation of + .21, recognition shows a correlation of + .15, the auditory memory test a correlation of + .145 with all others; these are the only correlations of significant magnitude.

TABLE XV

L. A6. SEVENTEEN BOYS

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.68	+.04	—.21	+.04	+.01	—.09	—.41	—.03
Add.	+.68		—.01	+.05	+.14	—.21	—.55	—.40	—.09
Speed	+.04	—.01		—.85	—.31	+.36	—.17	+.02	+.24
Acc.	—.21	+.05	—.85		+.42	—.46	+.32	+.51	—.04
Compl.	+.04	+.14	—.31	+.42		+.59	+.15	+.49	+.31
Canc.	+.01	—.21	+.36	—.46	+.59		+.14	+.22	—.03
Aud.	—.09	—.55	—.17	+.32	+.15	+.14		+.88	+.48
Vis.	—.41	—.40	+.02	+.51	+.49	+.22	+.88		+.36
Recog.	—.03	—.09	+.24	—.04	+.31	—.03	+.48	+.36	
All Tests	+.14	+.048	—.087	—.032	+.24	+.077	+.145	+.21	+.15

Table XVI. W. a5. 15 Girls

In this table it is seen that the completion test, sometimes said to be a good test for general intelligence, shows on the whole no correlation with the other tests. The lack of correlation between recognition and auditory memory is marked, and the correlation between visual memory and recognition is low (+ .28). Memory for visual and memory for auditory digits correlate to the extent of + .48; multiplication and addition show the high correlation of + .88.

TABLE XVI

W. a5. Fifteen Girls

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.88	+.36	—.13	+.09	+.47	+.05	+.01	—.12
Add.	+.88		.00	.00	+.16	+.35	—.01	+.18	+.06
Speed	+.36	.00		—.86	—.56	+.03	+.02	+.10	—.69
Acc.	—.13	.00	—.86		+.31	+.04	—.10	+.03	+.44
Compl.	+.09	+.16	—.56	+.31		—.08	+.02	+.01	—.26
Canc.	+.47	+.35	+.03	+.04	—.08		+.43	+.26	—.30
Aud.	+.05	—.01	+.02	—.10	+.02	+.43		+.48	—.13
Vis.	+.01	+.18	+.10	+.03	+.01	+.26	+.48		+.28
Recog.	—.12	+.06	—.69	+.44	—.26	—.30	—.13	+.28	
All Tests	+.201	+.202	—.20	—.033	—.039	+.15	+.095	+.198	—.085

Table XVII. W. a5. 13 Boys

There is notable here a high negative correlation (—.95) between speed and accuracy. The completion test correlates negatively with the computation tests—positively, to some extent, with memory and recognition. In three of the preceding groups the facts have been just the opposite. Addition and multiplication in this, as in all preceding groups, correlate highly (+.74). Visual and auditory memory also show a positive correlation (+.30). Auditory (+.13) and visual memory (+.14) and multiplication (+.11) are the only tests which show a noticeable correlation with all the others.

TABLE XVII

W. a5. Thirteen Boys

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.74	—.24	+.38	—.18	+.04	+.18	+.30	—.31
Add.	+.74		—.16	+.06	—.45	+.01	—.03	—.23	—.26
Speed	—.24	—.16		—.95	+.26	+.04	—.68	.00	—.39
Acc.	+.38	+.06	—.95		—.22	+.01	+.77	+.25	+.46
Compl.	—.18	—.45	+.26	—.22		+.11	+.24	+.45	+.31
Canc.	+.04	+.01	+.04	+.01	+.11		—.07	.00	+.02
Aud.	+.18	—.03	—.68	+.77	+.24	—.07		+.30	+.34
Vis.	+.30	—.23	.00	+.25	+.45	.00	+.30		+.07
Recog.	—.31	—.26	—.39	+.46	+.31	+.02	+.34	+.07	
All Tests	+.113	—.04	—.262	+.095	+.065	+.02	+.131	+.142	+.03

Table XVIII. E. b6. 19 Girls

Only two high positive correlations are found in this table: multiplication has a correlation of + .74 with addition; and visual memory of + .82 with auditory memory. A fair correlation, however, is found between multiplication and cancellation (+ .43); between addition and completion (+ .47); between addition and cancellation (+ .47); and between addition and auditory memory (+ .41). Visual memory shows a correlation of + .346 with all tests; multiplication, addition and completion also show correlations of over + .20 with all others. Speed correlates positively to but a small extent with most of the tests, while accuracy shows a negative correlation of about equal magnitude.

TABLE XVIII

E. b6. Nineteen Girls

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.74	+.21	—.30	+.17	+.43	+.14	+.16	+.12
Add.	+.74		+.21	—.40	+.47	+.47	+.41	+.25	+.11
Speed	+.21	+.21		—.39	+.59	+.12	+.29	+.37	—.37
Acc.	—.30	—.40	—.39		—.18	—.10	—.28	—.09	+.32
Compl.	+.17	+.47	+.59	—.18		+.17	+.29	+.23	—.03
Canc.	+.43	+.47	+.12	—.10	+.17		—.39	+.21	—.33
Aud.	+.14	+.41	+.29	—.28	+.29	—.39		+.82	+.13
Vis.	+.16	+.25	+.37	—.09	+.23	—.21	+.82		—.19
Recog.	+.12	+.11	—.37	+.32	—.03	—.33	+.13	—.19	
All Tests	+.21	+.28	+.13	—.178	+.213	+.02	+.176	+.346	—.03

Table XIX. E. b6. 11 Boys

A very high correlation (+ .93) is shown in this table between the two forms of memory test; a high correlation (+ .79) is also shown between addition and multiplication. The completion test shows a negative correlation with arithmetic, which is of about the same magnitude as the positive correlations between the same tests found among the girls of the same class. The cancellation test shows a correlation of + .44 with speed of movement. The very high negative correlation between the computation tests and both forms of memory is exceptional. The recognition test shows the highest general correlation, which, however, amounts to but + .15; multiplication shows a general correlation of —.10, which is chiefly due to the very large negative correlations which that function made with the memory tests. No noticeable general correlation is shown by any of the other tests.

TABLE XIX

E. b6. Eleven Boys

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.79	+.11	+.16	—.21	+.25	—.89	—.86	—.19
Add.	+.79		+.10	+.62	—.40	.00	—.59	—.48	+.01
Speed	+.11	+.10		—.83	+.71	+.44	—.01	—.22	+.44
Acc.	+.16	+.62	—.83		—.50	—.22	—.14	+.04	—.22
Compl.	—.21	—.40	+.71	—.50		+.18	+.07	—.08	—.14
Canc.	+.25	.00	+.44	—.22	+.18		—.15	—.15	+.27
Aud.	—.89	—.59	—.01	—.14	+.07	—.15		+.93	+.58
Vis.	—.86	—.48	—.22	+.04	—.08	—.15	+.93		+.50
Recog.	—.19	+.01	+.44	—.22	—.14	+.27	+.58	+.50	
All Tests	—.105	+.62	+.092	—.13	—.046	+.077	—.025	—.04	+.155

Table XX. L. b6. 19 Girls

The correlation between multiplication and addition is strongly positive (+ .66), as is that of auditory and visual memory (+ .56), although both are lower than usual; while those of completion and arithmetic, as of arithmetic and memory, are higher than usual. With the exception of accuracy, all functions show fairly high correlations with each other in this table. The completion test stands at the head in general correlation (+ .368) ; next is auditory memory (+ .343) and visual memory (+ .333) ; which are only slightly superior to addition and multiplication, with correlations of + .347 and + .325 respectively.

TABLE XX

L. b6. Nineteen Girls

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.66	+.25	—.12	+.46	+.16	+.64	+.45	+.10
Add.	+.66		+.35	—.11	+.70	+.32	+.37	+.54	—.05
Speed	+.25	+.35		—.70	+.64	+.14	+.58	+.54	+.03
Acc.	—.12	—.11	—.70		—.12	+.03	—.25	—.40	+.19
Compl.	+.46	+.70	+.64	—.12		+.09	+.52	+.60	+.06
Canc.	+.16	+.32	+.14	+.03	+.09		+.14	+.26	—.17
Aud.	+.64	+.37	+.58	—.25	+.52	+.14		+.56	+.19
Vis.	+.45	+.54	+.54	—.40	+.60	+.26	+.56		+.15
Recog.	+.10	—.05	+.03	+.19	+.06	—.17	+.19	+.15	
All Tests	+.325	+.347	+.23	—.185	+.368	+.121	+.343	+.333	+.062

Table XXI. L. b6. 11 Boys

Again we find a high correlation between multiplication and addition (+ .73), as well as between memory for visual and memory for auditory digits (+ .82). It is of interest to compare the correlations here with those of the girls in the same class, with regard to the completion test. With the girls the correlations were mostly positive, and a coefficient of + .368 was found with all the others. With the boys the correlations are nearly all of a decidedly negative character, and the average correlation with all tests would be much more strongly negative were it not for the singularly high positive correlation of + .51 which this test shows with recognition. This same difference between the boys and girls with regard to the correlations in which the completion test is concerned, has been found in several classes above. Most of the tests show a very slight positive correlation with all others, in this table, but none are sufficiently large to be significant.

TABLE XXI

L. b6. Eleven Boys

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.73	+.29	—.32	—.02	+.52	—.39	—.16	+.32
Add.	+.73		+.28	—.65	+.16	+.30	—.37	—.01	+.28
Speed	+.29	+.28		—.90	—.01	+.44	—.08	.00	+.11
Acc.	—.32	—.65	—.90		—.04	—.30	+.12	+.04	—.01
Compl.	—.02	+.16	—.01	—.04		—.30	—.22	—.35	+.51
Canc.	+.52	+.30	+.44	—.30	—.30		+.07	+.16	+.27
Aud.	—.39	—.37	—.08	+.12	—.22	+.07		+.82	—.29
Vis.	—.16	—.01	.00	+.04	—.35	+.16	+.82		—.42
Recog.	+.32	+.28	+.11	—.01	+.51	+.27	—.29	—.42	
All Tests	+.12	+.09	+.016	+.257	—.033	+.145	—.042	+.01	+.096

Table XXII. W. b6. 11 Girls

The most singular trait shown by this table is the presence of negative correlations between visual memory and nearly all of the other functions. The completion test shows no correlation with the computation tests, but shows a fair correlation with the memory tests and recognition tests. Speed of movement shows a very high correlation (+ .94) with cancellation; multiplication shows a high correlation with addition; but auditory and visual memory show a smaller correlation than normally. No test shows a noticeable general correlation, save the completion test in which the coefficient is + .21.

TABLE XXII

W. b6. Eleven Girls

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.78	—.27	+.44	+.08	+.09	.00	—.13	—.22
Add.	+.78		—.27	+.76	.00	+.19	—.25	—.37	—.12
Speed	—.27	—.27		—.69	+.19	+.94	—.60	—.18	+.63
Acc.	+.44	+.76	—.69		—.07	—.66	+.11	—.05	—.38
Compl.	+.08	.00	+.19	—.07		+.26	+.36	+.30	+.57
Canc.	+.09	+.19	+.94	—.66	+.26		—.38	—.35	+.73
Aud.	.00	—.25	—.60	+.11	+.36	—.38		+.30	—.15
Vis.	—.13	—.37	—.18	—.05	+.30	—.35	+.30		—.18
Recog.	—.22	—.12	+.63	—.38	+.57	+.73	—.15	—.18	
All Tests	+.096	+.09	—.031	—.067	+.211	+.102	—.076	—.082	+.11

Table XXIII. W. b6. 17 Boys

With the boys again, the completion test is negatively correlated with arithmetic, the figures being —.32 for multiplication, and —.10 for addition. No large correlations are shown by this group, save one of —.87 for speed and accuracy, one of +.80 for addition and multiplication, and one of +.64 for visual and auditory memory. Each of the tests shows a small positive correlation with all others, the largest being +.22, found in cancellation, visual memory and auditory memory.

TABLE XXIII

W. b6. Seventeen Boys

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.80	+.21	+.01	—.32	+.31	—.08	+.04	+.06
Add.	+.80		+.06	—.05	—.10	+.66	+.04	+.11	—.18
Speed	+.21	+.06		—.87	+.33	+.25	+.58	+.33	—.03
Acc.	+.01	—.05	—.87		—.09	+.02	—.39	—.23	—.15
Compl.	—.32	—.10	+.33	—.09		+.23	+.51	+.49	+.27
Canc.	+.31	+.66	+.25	+.02	+.23		+.32	+.29	—.26
Aud.	—.08	+.04	+.58	—.39	+.51	+.32		+.64	+.20
Vis.	+.04	+.11	+.33	—.23	+.49	+.29	+.64		+.13
Recog.	+.06	—.18	—.03	—.15	+.27	—.26	+.20	+.13	
All Tests	+.13	+.167	+.107	—.193	+.167	+.227	+.227	+.225	+.05

Tables XXIV and XXV. Average Results for Each Sex

In the average results, the differences between the sexes do not appear very striking. The correlation of certain tests, however, show distinct differences: in the correlation of multiplication and completion, the girls show a positive correlation of + .27 while the boys show a negative coefficient of — .05; in multiplication and auditory memory, the girls have a coefficient of + .16 while the boys have a correlation of — .17; in case of multiplication and visual memory, the girls show a slight positive correlation (+ .09) while the boys show a negative correlation of — .24; and the coefficients for multiplication with all other tests is for the girls + .17, and for the boys + .06. Very similar differences between the sexes are shown in the correlations of addition with other tests, both singly and all together. Other correlations show but small differences between sexes except that the correlation of completion with all other tests is for the girls + .15 and for the boys + .09; a difference which results largely from the fact that among the girls completion correlates positively with computations, but negatively among the boys.

TABLE XXIV

Average Correlation of Tests of All the Girls' Groups

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.		+.71	—.02	+.09	+.27	+.17	+.16	+.09	+.07
Add.	+.71		—.04	+.11	+.26	+.23	+.07	—.04	+.11
Speed	—.02	—.04		—.68	+.17	+.25	+.02	+.16	—.07
Acc.	+.09	+.11	—.68		—.04	—.13	—.02	—.03	+.13
Compl.	+.27	+.26	+.17	—.04		+.12	+.18	+.20	+.05
Canc.	+.17	+.23	+.25	—.13	+.12		+.01	.00	+.04
Aud.	+.16	+.07	+.02	—.02	+.18	+.01		+.57	+.09
Vis.	+.09	—.04	+.16	—.03	+.20	.00	+.57		+.10
Recog.	+.07	+.11	—.07	+.13	+.05	+.04	+.09	+.10	
All Tests	+.19	+.17	—.02	—.09	+.15	+.08	+.13	+.13	+.06

TABLE XXV

AVERAGE CORRELATION OF TESTS OF ALL THE BOYS' GROUPS

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.......		+.73	+.09	—.02	—.05	+.23	—.17	—.24	.00
Add.	+.73		+.06	+.01	—.10	+.22	—.20	—.22	+.01
Speed	+.09	+.06		—.87	+.25	+.33	—.12	+.02	+.12
Acc.........	—.02	+.01	—.87		—.10	—.21	+.20	+.11	—.01
Compl. ..	—.05	—.10	+.25	—.10		+.16	+.09	+.16	+.29
Canc.......	+.23	+.22	+.33	—.21	+.16		+.03	+.06	+.14
Aud.	—.17	—.20	—.12	+.20	+.09	+.03		+.57	+.25
Vis.	—.24	—.22	+.02	+.11	+.16	+.06	+.57		+.11
Recog.....	.00	+.01	+.12	—.01	+.29	+.14	+.25	+.11	
All Tests	+.09	+.06	—.01	—.11	+.09	+.12	+.08	+.07	+.11

Table XXVI. Average of All Preceding Tables

The table above is computed by averaging the figures of the twelve groups which have just been considered. It is evident that no single test has a high correlation with all of the tests taken together. Multiplication with a coefficient of + .132 is the highest, and this is so low as to be of little significance. The completion test and the addition test, with correlations of + .12, follow in rank, and are only slightly higher than the correlation of + .11 shown both by the cancellation test and the visual memory test, or than the correlation of + .103 shown by the recognition test. The average correlation for all of the other tests are almost zero.

TABLE XXVI

AVERAGE CORRELATION OF TESTS OF ALL GROUPS OF BOTH SEXES

	Mult.	Add.	Speed	Acc.	Compl.	Canc.	Aud.	Vis.	Recog.
Mult.......		+.72	+.03	+.04	+.11	+.20	—.01	—.07	+.04
Add.	+.72		+.01	+.07	+.07	+.24	—.06	—.13	—.07
Speed	+.03	+.01		—.76	+.21	+.29	—.06	+.09	+.03
Acc.........	+.04	+.07	—.76		—.07	—.17	+.09	+.08	+.14
Compl. ..	+.11	+.07	+.21	—.07		+.15	+.14	+.18	+.17
Canc.......	+.20	+.24	+.29	—.17	+.15		+.03	+.04	+.09
Aud.	—.01	—.06	—.06	+.09	+.14	+.03		+.57	+.17
Vis.	—.07	—.13	+.09	+.08	+.18	+.04	+.57		+.11
Recog.....	+.04	+.07	+.03	+.14	+.17	+.09	+.17	+.11	
All Tests	+.132	+.12	—.02	—.072	+.12	+.11	+.096	+.11	+.103

2. *Correlation of Test with Test*

Tables XXVII to XXX are arranged to show more clearly the average correlations of single tests, and the variations which are found between groups and between sexes.

(1) *Multiplication—addition.*—The correlation between these two functions is the largest found among the tests in this work. The average coefficient of + .72 is significant, especially in view of the fact that a similar positive correlation is repeated by every group of either sex.

(2) *Multiplication—speed.*—There is no correlation shown in the aggregate. In some groups the coefficient is negative; in others, positive. No sex differences are evident.

(3) *Multiplication—accuracy.*—There is no correlation on the whole. Generally a group which shows a positive correlation between speed and multiplication shows a negative correlation between accuracy and multiplication, or *vice versa.* There are no sex differences.

(4) *Multiplication—completion.*—A positive correlation of + .276 exists among the girls, and a negative correlation of — .056 among the boys. All of the girl groups and two of the boy groups show a positive correlation—a fair yet not satisfying evidence of a sex difference. Taking all the groups together, the positive correlation is very small.

(5) *Multiplication—cancellation.*—A small positive correlation is repeated in eleven of the twelve groups, with no sex differences.

(6) *Multiplication—auditory memory.*—There is no correlation on the whole. The girls show various small correlations of a positive sort, while the boys in four cases out of six show a negative correlation. A sex difference is slightly but not satisfactorily indicated.

(7) *Multiplication—visual memory.*—The correlations here are much the same as those found with auditory memory, although the sex differences are even less apparent.

(8) *Multiplication—recognition.*—No correlation on the

whole appears. There are large variations between groups, and no sex differences.

TABLE XXVII

	Multipl. Addition	Multipl. Speed	Multipl. Accur.	Multipl. Compl.	Multipl. Canc.	Multipl. Aud.	Multipl. Vis.	Multipl. Recog.
GIRLS—								
E. A6	+.49	—.24	+.31	+.42	+.48	+.12	+.01	+.03
L. A6	+.74	—.46	+.37	+.44	—.58	+.05	+.05	+.50
W. A5	+.88	+.36	—.13	+.09	+.47	+.05	+.01	—.12
E. B6	+.74	+.21	—.30	+.17	+.43	+.14	+.16	+.12
L. B6	+.66	+.25	—.12	+.46	+.16	+.64	+.45	+.10
W. B6	+.78	—.27	+.44	+.08	+.09	.00	—.13	—.22
BOYS—								
E. A6	+.64	+.15	—.14	+.35	+.26	+.21	—.34	+.17
L. A6	+.68	+.04	—.21	+.04	+.01	—.09	—.41	—.03
W. A5	+.74	—.24	+.38	—.18	+.04	+.18	+.30	—.31
E. B6	+.79	+.11	+.16	—.21	+.25	—.89	—.86	—.19
L. B6	+.73	+.29	—.32	—.02	+.52	—.39	—.16	+.32
W. B6	+.80	+.21	+.01	—.32	+.31	—.08	+.04	+.06
Average	+.722	+.034	+.037	+.11	+.203	—.005	—.073	+.035
	1	2	3	4	5	6	7	8

(9) *Addition—speed.*—Show no general correlation, but variations between groups, without sex differences.

(10) *Addition—accuracy.*—Show no correlation. The correlation for any given group is generally the opposite of that found between addition and speed. There are no sex differences.

(11) *Addition—completion.*—There is no correlation on the whole. Positive correlations are more common among the girls, but sex differences are not clear.

(12) *Addition—cancellation.*—Show a positive correlation of + .24 in the average. A positive correlation is found for every group except three. Motor activities, recognition of digits and similar factors of attention are common to both of these functions. The correlation probably shows that to a certain extent these common factors determine the quantity and quality of work in either function. The average correlation found for multiplication and cancellation is nearly the same as that found here.

(13) *Addition—auditory memory.*—No correlation is shown in the average. No evidence of sex differences is shown.

(14) *Addition—visual memory.*—Small negative correlations on the whole are shown. Two groups show a coefficient of almost zero, four show a positive correlation, and six a negative—which would indicate that the average with a larger number of groups would approach zero. No sex differences are shown.

(15) *Addition—recognition.*—There is no correlation on the whole and no evidence of sex differences.

TABLE XXVIII

	Add. Speed	Add. Accur.	Add. Compl.	Add. Canc.	Add. Aud.	Add. Vis.	Add. Recog.
Girls—							
E. A6	+.02	+.03	+.17	+.44	—.16	—.05	+.04
L. A6	—.57	+.42	+.06	—.26	+.07	—.80	+.66
W. A5	.00	.00	+.16	+.35	—.01	+.18	+.06
E. B6	+.21	—.40	+.47	+.47	+.41	+.25	+.11
L. B6	+.35	—.11	+.70	+.32	+.37	+.54	—.05
W. B6	—.27	+.76	.00	+.19	—.25	—.37	—.12
Boys—							
E. A6	+.09	+.05	+.03	+.59	+.30	—.34	+.33
L. A6	—.01	+.05	+.14	—.21	—.55	—.40	—.09
W. A5	—.16	+.06	—.45	+.01	—.03	—.23	—.26
E. B6	+.10	+.62	—.40	.00	—.59	—.48	+.01
L. B6	+.28	—.65	+.16	+.30	—.37	—.01	+.28
W. B6	+.06	—.05	—.10	+.66	+.04	+.11	—.18
Average	+.093	.065	.07	+.24	—.064	—.13	+.065
	9	10	11	12	13	14	15

(16) *Speed and accuracy.*—There is a high negative correlation, repeated by all groups of both sexes. This, as has been said, probably shows a difference in method or general attitude, rather than a difference in ability.

(17) *Speed—completion.*—A small positive correlation in the average is shown. Eight groups show a positive correlation and two show negative correlations. On the whole there is no prominent correlation of either sort. No sex differences are clear.

(18) *Speed—cancellation.*—A positive correlation of + .29, on the whole, is shown. The results indicate that these twc

functions are positively correlated insofar as the motor factors are common. The attentive and discriminative factors peculiar to the cancellation test may account for the fact that the correlation, although positive, is not high. No sex differences are shown.

(19) *Speed—auditory memory.*—There is no correlation, on the whole, either positive or negative, and sex differences are not clear.

(20) *Speed—visual memory.*—No correlation is shown, on the whole. More frequent and greater positive correlations are found among the girls than among the boys.

(21) *Speed—recognition.*—No correlation appears. There are great differences in the results for different groups; some of them show positive, others negative, correlations. No sex differences are shown.

(22) *Accuracy—completion.*—These show no correlation in the average. No sex differences are evident.

TABLE XXIX

	Speed Accur.	Speed Compl.	Speed Canc.	Speed Aud.	Speed Vis.	Speed Recog.	Acc. Compl.
GIRLS—							
E. A6	—.74	+.16	—.08	—.20	—.18	+.12	+.04
L. A6	—.71	+.01	+.39	+.05	+.32	—.15	—.20
W. A5	—.86	—.56	+.03	+.02	+.10	—.69	+.31
E. B6	—.39	+.59	+.12	+.29	+.37	—.37	—.18
L. B6	—.70	+.64	+.14	+.58	+.54	+.03	—.12
W. B6	—.69	+.19	+.94	—.60	—.18	+.63	—.07
BOYS—							
E. A6	—.86	+.54	+.47	—.45	.00	+.37	—.18
L. A6	—.85	—.31	+.36	—.17	+.02	+.24	+.42
W. A5	—.95	+.26	+.04	—.68	.00	—.39	—.22
E. B6	—.83	+.71	+.44	—.01	—.22	+.44	—.50
L. B6	—.90	—.01	+.44	—.08	.00	+.11	—.04
W. B6	—.87	+.33	+.25	+.58	+.33	—.03	—.09
Average	—.76	+.212	+.29	—.055	+.09	+.025	—.07
	16	17	18	19	20	21	22

(23) *Accuracy—cancellation.*—A very slight negative correlation is shown. Seven groups show negative correlations ranging from — .08 to — .66; no noticeable positive correlations are

shown. Cancellation is correlated with speed rather than with accuracy of movement (see 18).

(24) *Accuracy—auditory memory.*—No correlation is shown, on the whole. The groups range in correlation from — .39 to + .77. No sex differences are shown.

(25) *Accuracy—visual memory.*—The correlation is about the same as for accuracy and auditory memory. No sex differences are shown.

(26) *Accuracy—recognition.*—Slight positive correlations are shown. The differences from group to group are so great, however, as to make it appear that the average correlation is purely accidental. There are no sex differences.

(27) *Completion—cancellation.*—A very small positive correlation is shown. Three groups, however, show negative correlation. There are no sex differences.

(28) *Completion—auditory memory.*—In general there is a small positive correlation, which is not shown by three groups. Sex differences are not discernible.

(29) *Completion—visual memory.*—Seven groups show a positive correlation; four, a negative; and one, no correlation; making an average of + .182. No sex differences can be made out.

TABLE XXX

	Acc. Canc.	Acc. Aud.	Acc. Vis.	Acc. Recog.	Compl. Canc.	Compl. Aud.	Compl. Vis.
Girls—							
E. A6	—.08	+.25	+.35	+.08	+.42	—.12	—.18
L. A6	.00	+.15	—.03	+.15	—.12	+.05	+.27
W. A5	+.04	—.10	+.03	+.44	—.08	+.02	+.01
E. B6	—.10	—.28	—.09	+.32	+.17	+.29	+.23
L. B6	+.03	—.25	—.40	+.19	+.09	+.52	+.60
W. B6	—.66	+.11	—.05	—.38	+.26	+.36	+.30
Boys—							
E. A6	—.32	+.49	+.08	—.11	+.19	—.18	—.05
L. A6	—.46	+.32	+.51	—.04	+.59	+.15	+.49
W. A5	+.01	+.77	+.25	+.46	+.11	+.24	+.45
E. B6	—.22	—.14	+.04	—.22	+.18	+.07	—.08
L. B6	—.30	+.12	+.04	—.01	—.30	—.22	—.35
W. B6	+.02	—.39	—.23	—.15	+.23	+.51	+.49
Average	—.17	+.087	+.075	+.14	+.145	+.14	+.182
	23	24	25	26	27	28	29

(30) *Completion—recognition.*—There is a total positive correlation of + .17, which is not shown by 25 per cent of the groups. There are no clear sex differences, although the boys tend more strongly to a positive correlation than do the girls.

(31) *Cancellation—auditory memory.*—No correlation, on the whole, is shown, and no sex differences.

(32) *Cancellation—visual memory.*—No correlation and no sex differences are shown.

(33) *Cancellation—recognition.*—No correlation is shown in the average. Sex differences are not clear, although the boys show more frequent and greater positive correlations than do the girls.

(34) *Auditory and visual memory.*—A positive correlation is shown, on the average. The correlation of these two functions in one case runs up to + .93, and is only slightly lower in several others. The general average is considerably reduced by a single negative correlation which appears in one small group of boys. No sex differences, however, are clear.

(35) *Auditory memory—recognition.*—Small positive correlation appears on the average, although three groups show negative correlations. There are no sex differences.

(36) *Visual memory—recognition.*—The average gives a small positive correlation, although there are three exceptions among the groups. At first thought it is somewhat surprising that visual memory and recognition should show so small a correlation. The processes, however, are widely different: the first requires a unique mental act of quickly spanning, retaining, and reproducing a series of discrete impressions; the second differs in the processes involved, since it does not depend so much upon the span of memory, or upon the necessity of keeping the whole series intact, as upon the speed of becoming familiar with the peculiar features of the individual impressions, and fixing them in mind; and it differs also with regard to material, since digits were used in the former test, and nonsense syllables in the latter. When these differences are appre-

ciated, it is not so surprising that the correlation of the two functions should be so low.

TABLE XXXI

	Compl. Recog.	Canc. Aud.	Canc. Vis.	Canc. Recog.	Aud. Vis.	Aud. Recog.	Recog. Vis.
GIRLS—							
E. A6	+.30	.00	—.26	+.37	+.86	+.45	+.49
L. A6	—.32	+.30	—.09	—.05	+.40	+.07	+.09
W. A5	—.26	+.43	+.26	—.30	+.48	—.13	+.28
E. B6	—.03	—.39	+.21	—.33	+.82	+.13	—.19
L. B6	+.06	+.14	+.26	—.17	+.56	+.19	+.15
W. B6	+.57	—.38	—.35	+.73	+.30	—.15	—.18
BOYS—							
E. A6	+.47	—.10	—.13	+.56	—.14	+.20	+.02
L. A6	+.31	+.14	+.22	—.03	+.88	+.48	+.36
W. A5	+.31	—.07	.00	+.02	+.30	+.34	+.07
E. B6	—.14	—.15	—.15	+.27	+.93	+.58	+.50
L. B6	+.51	+.07	+.16	+.27	+.82	—.29	—.42
W. B6	+.27	+.32	+.29	—.26	+.64	+.20	+.13
Average	+.17	+.025	+.035	+.09	+.571	+.172	+.108
	30	31	32	33	34	35	36

3. *Summary*

(1) Of the tests used in this work, none shows a high correlation with all the others taken together; the coefficient of + .14 in the case of multiplication is the highest. Most of the tests show no noticeable general correlation.

(2) High positive correlations are found only between those tests which are dependent upon what are obviously very similar activities; thus, the correlations of addition and multiplication and of auditory and visual memory are very high.

(3) Among the other tests, the correlations seem to be high or low according to the number of elements which any two functions possess in common. Thus, the computation tests and cancellation correlate to some extent (+ .25), apparently on account of common elements, such as familiarity with the digits and similarity of eye movement. Speed of movement correlates with cancellation (+ .29) on account of common motor elements.

(4) Large variations occur in the correlation of those tests which are less similar. Between two such tests, one group may show a positive correlation, another group a negative; a third may show no correlation. That is to say, a subject who is good in one of these functions may be good, bad, or indifferent in another comparatively dissimilar function.

(5) On the whole, sex differences in correlation cannot be made out.

4. *Conclusions*

These results have an interesting relation to the problem of mental tests in general. Throughout the investigations with mental tests, search has been diligently made for a test of general intelligence or general mental ability. In fact, tests very similar to the ones employed in this work have been proposed as meeting this requirement.

It has been a matter of no small difficulty to determine accurately whether a test is or is not a fair measure of general mental ability. A method often used is to compute coefficients of correlation of the work in the tests with class standing, school marks, and other estimations of mental ability dependent largely upon the judgment of individuals. Such correlations are of doubtful value, however, because there is no certainty that class standing, and the like, give a true measure of a pupil's general ability. It has been suggested that a test which best succeeds in measuring an individual's ability is one which correlates most highly with tests for different mental functions. From this point of view, the results stated in the above table give little indication that any of the tests employed in this work would serve the purpose.

The survey of the tables for the various groups, which has just been completed, has shown the existence of wide variations. For example, the correlation of the completion test with the memory tests is in some groups fairly high; with others it is near zero; with others it is negative; on the whole it seems to be not far from zero. Apparently with such dissimilar tests,

the results that will be obtained from any particular group is largely a matter of accident.

Many investigators have found fairly high correlations of a single test with several others, especially when the groups of subjects included a number of especially dull and especially bright pupils. It is evident, however, that the results of those investigations are not borne out by the facts here found. There are perhaps individuals whose ability in all forms of mental activity is low, as well as exceptional individuals whose ability is high in all; but the truth may also be, that the majority, who are grouped rather closely about the average, will be found to be slightly above the average ability in some forms and slightly below in other forms of mental accomplishment. In the investigation of these various functions, there should exist correlation, if the different tests employed involve common activities; but it would appear that the tests used in this research give a measure of ability in relatively specific and unrelated activities.

That this conclusion is not dependent upon accident is shown by the comparatively high correlations which are found between those tests which certainly measure related function (the arithmetical tests and the two memory tests). Correlations would be found also between other tests if there were any similar relationship between them.

VIII

The Effects of Practise on Mental Functions

The data used in the previous section lend themselves quite readily to a computation of the amount and rate of improvement due to practise. Individual variations—unusually good or poor performances due to chance or to various distracting influences—are certain to occur, but these are largely eliminated by considering the results of a class as a whole. The individual difference in efficiency at different times, due not to practise but to other causes, is neutralized, since the final average of

work done at any particular stage of practise is made up of the average performances of five separate squads, each of which worked at a different hour of the school day.

A grave defect in this material, as far as the computation of practise effects is concerned, lies in the irregular, and sometimes long, intervals between the practise periods. The practise periods themselves, however, are short, varying from ten or twelve seconds to two and a half minutes, according to the test. An additional source of error results from the use, in one or two of the tests, of material of different degrees of difficulty for the different practise periods; if the difference in the difficulty of the texts is large, practise effects are obscured.

1. *Practise Effects Shown by Different Groups*

The tables give the average performance of each class at the various periods, followed by an average for all the classes, and a statement of the average improvement in percentage of the average initial performance. The percentage of improvement is computed by finding the difference between the score of any given period and that of the first period, and dividing that difference by the score for the first period.

TABLE XXXII. MULTIPLICATION

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	39.02	2	41.80	5	41.38	1	41.92	1	45.18
L. a6	35.74	2	36.50	5	36.16	1	37.10	1	38.34
W. a5	32.80	1	36.08	4	34.26	2	35.54	1	37.30
E. b6	36.20	2	37.08	5	35.66	1	36.52	1	39.58
L. b6	30.70	2	31.62	5	31.84	1	32.64	1	35.44
W. b6	33.86	1	36.60	4	35.42	2	36.42	1	40.22
Average	34.73		36.61		35.78		36.69		39.34
Percentage of imp'v't	0.		5.4		3.0		5.6		13.2

On the whole, a continuous but irregular improvement is noted. The third day, however, shows no improvement over the second, although the amount of correct work done is 3 per cent greater than on the first day. This drop in the curve on

the third day is repeated by five of the six classes and in the sixth the improvement over the second day is only very slight, amounting to about two-thirds of 1 per cent. This drop occurs after a long interval between practise periods; the average interval between the second and third days is 4 2/3 days, whereas the average interval between any other two periods is less than two days. It might seem that the long lapse of time resulted in a loss of much of the efficiency that had been gained during the first two practise periods. If such were the case, it would appear in the results of the other tests which were given on the same days; but, as will be seen, this is by no means the case.

The last day's work shows an improvement over the first, amounting to 13.2 per cent. Since the largest improvement between periods occurs between the fourth and the last days, the indication is that continued practise beyond that point would have resulted in continued improvement.

The curve of all the classes agrees quite well with the average curve.

TABLE XXXIII. ADDITION

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	30.48	2	30.58	5	33.46	1	33.32	1	34.60
L. a6	27.74	2	29.20	5	30.48	1	30.38	1	31.88
W. a5	25.20	1	25.32	4	27.74	2	28.74	1	28.74
E. b6	27.08	2	27.40	5	29.48	1	29.46	1	32.84
L. b6	26.00	2	25.76	5	26.02	1	26.70	1	27.20
W. b6	30.64	1	32.74	4	33.00	2	33.98	1	35.18
Average	27.85		28.50		30.03		30.43		31.74
Percentage of imp'v't	0.		2.3		7.8		9.2		14.0

The average total improvement (14.0 per cent) in the case of addition is almost the same as was found in multiplication. The rate of improvement in the case of addition is more regular and the amount from period to period is more uniform. It is somewhat surprising that the drop in the curve following the long interval between practise periods (second to third day),

which was so pronounced in the figures for multiplication, is not found here, although the tests in addition were given just two minutes after the multiplication tests on the same days. In multiplication, not only does the average show a heavy drop on the third day, but the curves of nearly every class agree in that respect; while in the curves for addition there is in no group such a retardation in improvement. The situation illustrates to a nicety the danger of generalizing from a small accumulation of data, no matter how clear an indication the figures may give. If one had nothing but Table XXX, which shows, both on the average and by almost every class, a retardation in practise improvement after an extra-long interval, he would feel tempted to infer that the efficiency previously gained had largely deteriorated through disuse in an interval of such length. If, however, one should see nothing save Table XXXIII he would probably be ready to conclude that even an interval of five days is not sufficient to cause a lapse in ability gained through previous practise. Fortunately, we have the additional evidence of several other tests to bring to bear upon this contradiction.

TABLE XXXIV. SPEED OF MOVEMENT

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	49.84	2	44.68	5	40.52	1	53.66	1	36.84
L. a6	32.84	2	35.20	5	35.40	1	35.54	1	38.20
W. a5	32.44	1	32.60	4	37.56	2	34.94	1	34.40
E. b6	45.38	2	40.88	5	45.36	1	51.40	1	45.66
L. b6	27.82	2	28.58	5	31.62	1	33.62	1	35.96
W. b6	30.22	1	33.20	4	35.14	2	34.98	1	35.26
Average	36.42		35.85		37.60		40.69		37.72
Percentage of imp'v't	0.		—1.6		3.2		12.0		3.6

The rate and amount of improvement of speed of movement, such as that involved in the drawing test, is very irregular even in the final average, and the separate classes show fluctuations of considerable magnitude. On the whole, the second day's work is less in amount than the first, and the fifth is much less

than the fourth; but the results in some of the classes are quite different from the average. L a6, for example, shows a steady improvement throughout; W a5 shows its maximum on the third day, and other classes show peculiarities. The average shows no loss of ability on the third day on account of the long interval preceding it.

Overlooking the irregularities, it is evident that substantial improvement has been the result of practise. Fluctuations and irregularities are to be expected, and are enhanced in this case by the opportunity that is afforded for changes in the method of working. (See p. 63.) On that account the curve of improvement for speed should be compared with those for accuracy.

TABLE XXXV. ACCURACY

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	2.57	2	2.06	5	2.26	1	2.37	1	1.54
L. a6	1.56	2	1.73	5	1.90	1	1.83	1	1.80
W. a5	1.66	1	1.50	4	1.70	2	1.74	1	1.57
E. b6	1.93	2	1.73	5	2.23	1	2.20	1	1.87
L. b6	1.70	2	1.53	5	1.70	1	1.66	1	1.90
W. b6	1.73	1	1.83	4	1.66	2	1.66	1	1.87
Average	1.86		1.73		1.90		1.91		1.75
Percentage of imp'v't	0.		7.0		—2.1		—4.7		5.9

The course of improvement in accuracy considered by itself is very irregular; but viewed in comparison with the curve of improvement in speed, its irregularities have some meaning. The fall in the curve of speed on the second day is counterbalanced by the large improvement in accuracy. The third day shows a fall in accuracy and a slight improvement in speed; and when they are taken together, it would appear that the improvement is very small. This, then, is an approach to the situation found in the case of multiplication—i. e., a loss of efficiency following the long interval between practise periods. The very high improvement found in speed on the fourth day does not look so formidable when it is seen that at the same time a great loss in accuracy occurred. The last day shows an

improvement over the first in both speed and accuracy, so it seems that, on the whole, practise in this test has resulted in substantial improvement.

In an attempt to show, roughly at least, the trend of improvement of speed and accuracy combined, the mathematical treatment described on p. 69 ff has been applied to the figures. The results produced by this arbitrary method of treatment follow:

	Day 1	Day 2	Day 3	Day 4	Day 5
Average	36.42	37.80	37.00	39.94	39.37

The curve obtained is not uniform in its upward tendency, but on the whole it shows a decided improvement resulting from practise.

TABLE XXXVI. COMPLETION TEST

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	25.32	2	21.90	5	18.80	1	26.24	1	27.80
L. a6	21.88	2	18.60	5	20.58	1	23.50	1	26.20
W. a5	18.40	1	18.22	4	18.32	2	23.44	1	26.20
E. b6	21.24	2	20.40	5	16.36	1	24.56	1	27.00
L. b6	19.54	2	19.82	5	17.92	1	24.52	1	22.50
W. b6	20.14	1	18.46	4	15.80	2	24.06	1	23.40
Average	21.08		19.56		17.96		24.38		25.51
Percentage of imp'v't	0.		—2.9		—17.2		17.7		23.8

The course of improvement in this test is so complicated by the difference in difficulty of the texts used on the several days, that it cannot be made out with certainty. The large decrease in the amount of work done on the second and third days is undoubtedly due for the most part to the greater difficulty of the texts, but it is impossible to tell to just what extent this is the case. The fourth period shows a large and the fifth a larger increase, over the first day, in the amount of work done, but here again the results may be in part due to the ease of the texts used on those days.

TABLE XXXVII. CANCELLATION TEST[103]

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
L. a6	32.82	2	36.20	5	37.62	1	41.16	1	42.80
W. a5	33.46	1	37.30	4	39.42	2	42.14	1	45.38
L. b6	34.96	2	39.20	5	41.48	1	43.66	1	46.40
W. b6	31.78	1	35.78	4	39.40	2	40.06	1	42.84
Average	33.25		37.12		39.48		41.76		44.35
Percentage of imp'v't	0.		11.6		18.8		25.6		33.3

The figures for the cancellation test show a very regular and uniform, as well as a very large, improvement due to practise. Each class follows closely the curve shown by the general average. The fact that the same text was used in every period may account to some extent for the uniformity of the improvement. There is no indication of a retardation due to the long interval following the third day.

Considering the short time of practise (one minute) given in this test, the total improvement, which amounts to 33.3 per cent, seems great. And the fact that the same text was used throughout gives one a suspicion that the pupils might have memorized more or less completely the arrangement of the digits, or figured out various "short cuts" and time-saving devices. It seems unlikely, however, that the arrangement or position of the digits could be consciously held in mind; and as can be readily determined from an examination of the text (p. 90), the opportunity for striking out two symbols at one stroke and of employing other such methods is extremely small. Apparently the subject learns rapidly to overlook the distracting stimuli and to single out with increasing ease the symbol sought. Along with this improvement, there develops, perhaps, a facility in striking out the digits with less conscious attention.[104]

[103] The results from E. a6 and E. b6 were not used because of a change in the length of the working period made in the midst of the series of tests.

[104] It is probable also that in this, as in all the previous tests except the drawing test, facility in turning the papers at the word "go" developed. Improvement in this act would be included in that of the functions shown in the tables.

TABLE XXXVIII. AUDITORY MEMORY

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	4.64	2	4.42	5	4.80	1	5.55	1	5.38
L. a6	5.82	2	5.56	5	5.66	1	6.12	1	6.40
W. a5	4.94	1	5.10	4	5.40	2	5.74	1	5.54
E. b6	4.60	2	4.06	5	4.78	1	5.24	1	5.14
L. b6	4.62	2	4.46	5	4.72	1	5.28	1	5.52
W. b6	5.14	1	5.88	4	5.58	2	5.94	1	5.76
Average	4.96		4.91		5.15		5.64		5.62
Percentage of Imp'v't	0.		1.0		3.8		13.7		13.3

In this function a substantial and fairly regular improvement is shown by the averages, although there is considerable variation from group to group. The average shows no improvement on the second day as a result of practise on the first day, and such is the case with four of the six individual classes. The last day is, on the whole, slightly inferior to the fourth, but it shows a great improvement over all other days. The improvement of the third day over the second is about five per cent, an amount which is smaller than the improvement of the fourth over the third; but, in view of the fact that the second and fifth days show no improvement whatever over the day preceding, there is no evidence that the long interval between periods (from the second to the third) has caused a retardation.

TABLE XXXIX. VISUAL MEMORY

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	5.00	2	5.18	5	5.40	1	5.28	1	5.30
L. a6	5.06	2	5.80	5	5.86	1	6.52	1	6.76
W. a5	5.46	1	5.18	4	5.44	2	6.12	1	5.56
E. b6	4.78	2	4.90	5	5.14	1	6.12	1	5.80
L. b6	4.22	2	4.14	5	4.62	1	5.84	1	5.24
W. b6	5.84	1	5.56	4	5.42	2	5.84	1	5.74
Average	5.06		5.12		5.31		5.95		5.76
Percentage of Imp'v't	0.		1.1		4.9		17.3		13.6

The general course in this function is similar to that found in the case of auditory memory. The maximum improvement

is somewhat greater; the decrease at the second period is not noticeable in the general average, although it appears in that of three of the classes; the fifth period shows a smaller accomplishment than the fourth, both in the average result and in the case of four of the six groups. There is no clear indication of a decrease in efficiency in this function on account of the long interval between the second and third days.

TABLE XL. RECOGNITION

Class.	Day 1	Interval (Days)	Day 2	Interval (Days)	Day 3	Interval (Days)	Day 4	Interval (Days)	Day 5
E. a6	7.64	2	7.48	5	7.68	1	8.18	1	7.98
L. a6	6.92	2	7.20	5	7.30	1	7.78	1	7.08
W. a5	7.56	1	6.94	4	7.70	2	7.60	1	7.44
E. b6	7.82	2	7.88	5	8.08	1	8.34	1	8.12
L. b6	6.98	2	6.64	5	7.00	1	7.24	1	6.94
W. b6	7.04	1	6.88	4	7.54	2	7.90	1	7.14
Average	7.32		7.17		7.55		7.84		7.45
Percentage of imp'v't	0.		—2.05		3.1		7.1		1.7

Again, improvement seems to have reached its maximum on the fourth day. It is not at all probable that the pupils have reached their limit of improvement in so short a time. Some of the fluctuations shown in this curve may be due to a difference in the difficulty of texts, since the nonsense syllables in some cases are easily remembered and recognized. Some of the syllables may be closely associated with nick-names, slang words and the like. There is a possibility also that the decline on the fifth day, shown by the last three tests, may have been in part due to excitement, nervousness, or overstrain produced by the knowledge that it was their last day in the test work.

The course of improvement in memory for visual and auditory digits and for recognition of nonsense syllables agrees in showing no retardation due to the long interval between the second and third days of practise.

2. *Comparison of Practise Effects in the Different Functions*

The following table gives a comparison of the average percentage of improvement through the course of practise, the work done on the first day serving as a basis of comparison.

TABLE XLI. PERCENTAGE OF IMPROVEMENT IN DIFFERENT FUNCTIONS

	Day 1	Day 2	Day 3	Day 4	Day 5
Multiplication	100.	105.4	103.	105.6	113.2
Addition	100.	102.3	107.8	109.2	114.
Speed and accuracy combined	100.	103.8	101.6	109.4	108.1
Completion	100.	97.1	92.8	117.7	123.8
Cancellation	100.	111.6	118.8	125.6	133.3
Auditory memory	100.	99.0	103.8	113.7	113.3
Visual memory	100.	101.1	104.9	117.3	113.3
Recognition	100.	97.9	103.1	107.1	101.7
Average	100.	102.3	104.4	113.2	115.1

One thing at least is quite certain, that in all the mental functions tested, improvement is shown. Another fact appears to be equally evident, that the amount of improvement in some functions is greater than that in others. Yet accurately to compare the differences in improvement shown by the various functions is not a simple, and perhaps not a possible, task. Several factors are present which complicate the matter; and if accurate results are to be obtained, these factors must be taken into account.[105]

(1) To begin with, the initial performance in any function (at least those in the present tests) is not zero, nor is it very close to zero. The subjects have all had previous practise in the identical function, or in activities of which the function is a complex, and consequently the initial performance represents a certain stage of practise. Just what the stage is we are quite unable to determine. We might think, for example, that the pupils at the beginning of the tests have advanced, by previous

105 For an excellent discussion of commensurability of gains in different functions see Thorndike, E. L., *Educational Psychology*, vol. II (1913), pp. 165-177.

practise in school work, more nearly to their limit of improvement in addition than in the cancellation test, and if such were the case we should expect a greater amount of improvement in the latter, other things being equal. But any assumption of this sort, especially with regard to the amount of this difference, would be hazardous; the situation would have to be experimentally determined.

(2) Another difficulty lies in the method of computing the differences. Absolute differences or percentile differences at various stages of practise in one function cannot always with fairness be compared to such differences in another. Thorndike gives a good illustration of this fact:

> Suppose that he comes to secure 80 instead of 200 at golf by one year of practise; and 160 instead of 400 in errors made per thousand "chances" in baseball, in the same amount of practise. . . . The former is the change from the first day's play of a "rank beginner" to that of the tip-top experts of the world. The latter is only the change from low mediocrity to less low mediocrity.[106]

(3) Another factor which varies greatly from function to function in the present series of tests, is the amount of time allotted for practise at each sitting. The tests in memory for digits required eight seconds for exposure, and about fourteen seconds to complete the whole test; while the subjects worked for two and a half minutes in the completion test. The time allowed for the other tests varies between these two extremes.

(4) Moreover, as has been mentioned, the difference in the difficulty of the texts used on the various days may on some occasions mask and on others accentuate the efforts of practise. This was evidently true in case of the completion test and probably in the recognition test, but in the others, such as the computation and memory tests, the differences could hardly be sufficient to modify seriously the results.

In the face of these facts, a comparison of improvement for the several functions can offer us little more than a suggestion. It is noticeable, however, that the most rapid and most regular improvement occurs in the cancellation test, in

[106] Thorndike, *op. cit.*, p. 166.

which the time of practise was but one minute and in which the same text was used throughout. The improvement shown by addition is very nearly identical with that of multiplication, and this amount is quite large considering the common use of this function in the school and the length of the practise period (two minutes). The percentage of improvement shown by memory for visual and for auditory digits is very nearly the same, and the total amount of gain in these functions is about equal to that in arithmetic. The gains for the recognition test are comparatively small and irregular; this may be partly due to differences in the difficulty of texts used and to changes in the method of learning. In the completion test practise effects cannot well be discussed on account of the varying difficulty of the texts employed.

(3) *Summary of Results.*

(1) All of the functions tested show improvement, due to practise, in amounts varying from 7 to 33.3 per cent.

(2) The rate and amount of improvement vary considerably for the different groups. The influence of various accidental conditions—changes of method and differences in the difficulty of texts—accounts in part for the fluctuations in the improvement; differences in amount of improvement may result from differences in initial ability, in native capacity for improvement, as well as from factors such as interest, vigor of application and environment.

(3) The rate of improvement is not uniform for the different functions, although, for reasons mentioned above, the quantitative differences between functions cannot be demonstrated. It will be noted, however, that those functions whose correlations were high and positive (multiplication and addition; visual and auditory memory) show almost identical amounts of improvement.[108]

[108] It should not be thought, however, that the correlations previously given are dependent on practise effects, for the figures used in ranking were not the scores of the last test, but the total score for all the tests.

(4) On the whole, there is no satisfactory indication of a retardation of improvement due to the one long (4 or 5-day) interval. Such a retardation does appear in the results of three functions, in one of which (accuracy), however, it is not clear, and in another (completion) it is perhaps entirely due to the greater difficulty of the text used at the time. When it is noticed also that similar decreases are apparent even earlier in the series of practise periods (second period of the recognition and auditory memory tests), as well as later in cases where the interval is small, it is only reasonable to conclude that the length of the interval has no serious influence on the course of improvement.

(5) The indications of the curves of improvement in general are that the limit was far from being reached. With continued practise, a continuation of improvement would be expected.

IX

Sex Differences

Table XLII gives the average score of the girls and of the boys of each class.

(1) *Multiplication.*—The girls, on the whole, show a superiority in multiplication, amounting to 10.3 per cent. In four of the six classes the girls are superior, but in two (W. a5 and L. b6) the boys lead. A definite conclusion, however, is prevented by the failure of the average results to be repeated by every group of subjects. We can say, at the most, that in any group the likelihood is that the girls will show a superiority over the boys.

(2) *Addition.*—In this form of computation the girls show an average superiority of 11.4 per cent. The boys are superior in addition in the same two classes in which they were superior in multiplication. Sex differences consequently do not appear with perfect clearness.

TABLE XLII

SHOWING THE SEX DIFFERENCES FOR ALL GROUPS IN ALL FUNCTIONS

	Multipl.	Add.	Speed	Acc.[109]	Compl.	Canc.	Aud. Mem.	Vis. Mem.	Recog.
BOYS—									
E. A6	38.2	30.5	44.0	2.27	21.2	51.0	4.65	5.03	7.70
L. A6	32.8	27.5	35.0	1.88	21.4	36.7	5.76	5.70	6.76
W. A5	37.3	27.8	35.8	1.90	20.4	38.5	5.2	5.5	7.4
E. B6	30.6	25.0	49.4	2.42	22.5	44.7	4.6	5.08	7.9
L. B6	32.7	25.7	31.0	1.64	18.3	38.0	4.7	4.35	6.78
W. B6	37.0	32.2	40.0	2.19	20.3	38.0	5.6	5.2	7.3
Average	34.7	28.1	38.9	2.05	20.7	41.1	5.08	5.14	7.31
GIRLS—									
E. A6	47.8	38.1	37.0	2.33	26.8	61.2	5.3	5.54	8.4
L. A6	39.9	32.0	33.8	1.7	22.0	39.2	6.1	6.42	7.5
W. A5	35.7	26.8	31.5	1.64	20.5	39.7	5.4	5.71	7.8
E. B6	40.2	31.4	41.0	1.67	23.0	54.0	4.8	5.14	8.32
L. B6	30.7	26.4	33.2	1.63	22.0	42.2	5.18	5.36	7.1
W. B6	36.0	33.0	33.5	1.69	23.3	39.5	5.7	5.62	7.6
Average	38.3	31.3	35.0	1.77	22.9	45.9	5.41	5.63	7.78
Superiority per cent	G 10.3	G 11.4	B 11.1	G 15.8	G 10.6	G 11.6	G 6.5	G 9.5	G 6.4

Other investigators have obtained results in general agreement with those above.

The work of Miss Holmes[110] indicated a superiority of the girls over the boys. In tests of addition upon children of the 4th, 5th, 6th, 7th and 8th grades she found:

	Errors	Corrections	Figures Added
Boys	15.9	15.2	703.
Girls	13.9	12.4	788.

The girls add more figures and make fewer errors and corrections.

Fox and Thorndike[111] found that among high-school pupils the girls excelled by about 5 per cent, although such results

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109 The smaller number represents the greater accuracy.

110 Holmes, M. E., "The Fatigue of a School Hour", *Pedagogical Seminary*, vol. 3 (1895), pp. 213-224.

111 Fox, W. S., and Thorndike, E. L., "The Relationship between the Different Activities Involved in the Study of Arithmetic. Sex Differences in Arithmetical Ability", *Columbia Univ. Contributions to Phil., Psych., and Education*, vol 11 (1903), pp. 32-40.

were doubtful on account of the probability that the girls tested were otherwise of a better grade than the boys.

Thorndike[112], in another study, found that the degree of ability reached by 50 per cent of the girls was reached by 48 per cent of the boys.

(3) *Speed of Movement.*—The boys on the whole show a greater speed, amounting to 11.1 per cent. The case is similar in all the classes except L. b6, in which the girls are slightly superior.

So far as the writer knows, no previous investigations have been made for sex differences with this particular test.

For rate of tapping, however, Miss Thompson[113] found that, among adults, 88 per cent of the men exceeded the median speed of the women. Bolton[114] found, on the contrary, that the girls exceeded in speed of movement.

Wells[115] found that in extended experiments the women excelled at first, but later showed a rate slower than the men. The main sex-difference, according to Well's interpretation, is that the women are more responsive to the affective element of the experiment.

Burt and Moore,[116] in a later study, found the median speed for boys to be 86.5 and for girls 80.5 taps in fifteen seconds, and that 69.8 per cent of the boys exceed the median speed for the girls.

The conflicting testimony of the several investigators indicates that sex-differences cannot be made out with certainty. In the present work, the two factors, speed and accuracy of movement, are so intimately bound together, that the one can be rightly interpreted only in comparison with the other.

112 Thorndike, E. L., *Educational Psychology* (N. Y., 1903), p. 117.

113 Thompson, Helen B., *The Mental Traits of Sex* (Chicago, 1903), p. 188.

114 Bolton, T. L., "The Relation of Motor Power to Intelligence", *Amer. Journ. Psychol.*, vol. 14 (1903), pp. 615-631.

115 Wells, F. L., "Sex Differences in the Tapping Test: an Interpretation", *Amer. Journ. Psychol.*, vol. 20 (1909), pp. 353-363.

116 Burt, C., and Moore, R. C., "The Mental Differences Between the Sexes", *Journal of Experimental Pedagogy and Training College Record* (London), vol. 1 (1912), pp. 273-284, 355-388.

(4) *Accuracy of Movement.*—The average shows that the girls excel in accuracy by 15.8 per cent. Only in one class do the boys show a greater accuracy (E. a6).

Tests by Miss Thompson[117] with the aiming and "target" test show a slightly greater accuracy among the boys.

Bryan,[118] in tests with the electrical tracing-board, with 700 children, showed that for both hands the girls are superior to the boys in 35.3 per cent of the cases, the boys superior to the girls in 51.4 per cent, and the sexes were equal in 13.4 per cent of the cases.

Bolton[119] found that in steadiness of movement, as tested by an apparatus similar to the electric tracing board, the girls (9 years of age) excelled the boys by a smaller average number of contacts made during the tracing, as shown in the following table:

	(Right Hand)				Contacts (Left Hand)			
	In	Out	Down	Up	In	Out	Down	Up
Boys	22.9	22.7	19.2	19.5	25.3	24.8	24.0	22.3
Girls	16.8	18.5	17.1	20.6	21.4	23.4	22.8	24.8
Difference	6.1	4.2	2.1	—1.1	3.9	1.4	1.2	—2.5

The girls excel in all forms of movement save those upward.

In the maze test, which the writer has used, it is difficult, in fact impossible, to tell whether the results indicate anything in the way of a sex-difference in motor ability. Probably the differences here are not of ability in the functions themselves, but in method. The boys work with less care than the girls, with the result that they cover more ground but with a larger number of errors. The girls, who are more bent upon accuracy, are content with less speed.

If we apply to the figures the arbitrary mathematical treatment previously described (pp. 70 ff.), we find that the combined speed and accuracy are for boys 34.7, for girls 35.0. The girls,

117 *Op. cit.*, p. 17.

118 Bryan, W. L., "On the Development of Voluntary Motor Ability", *Amer. Journ. Psychol.*, vol. 5 (1892), pp. 123-204.

119 Bolton, T. L., "The Relation of Motor Power to Intelligence", *Amer. Journ. Psychol.*, vol. 14 (1903), pp. 615-631.

then, show a slight superiority, which, however, is too small to be significant, considering the possibilities of error in computation.

(5) *Completion Test.*—In the mental activities demanded by the completion test, the girls are superior to the boys by 10.6 per cent. The girls in every class show a similar superiority to the boys.

As far as the writer is aware, no previous investigations have been made with this test to show sex-differences.

(6) *Cancellation Test.*—The results indicate very clearly a superiority of girls over boys in this function. The same tendency is shown by all the classes, making on the average a superiority on part of the girls of 11.6 per cent.

Many investigators, using this and similar forms of cancellation tests, have reached essentially the same conclusions with regard to sex-differences. Cattell and Farrand,[120] using the "A-test" on students at Columbia University, found a difference of 12.7 per cent, in favor of the women, in the time required to complete the test.

Woodworth and Wells,[121] using the same form of test as that employed in the present work, find "that the women average distinctly faster than the men, 123 as against 145 seconds." The difference found by these investigators (17.9 per cent) is greater by 6.3 per cent than that found between boys and girls in the present work.

Burt[122] found that the girls cancelled 110, and the boys 99.5 letters of the "A-test" in two minutes. The superiority of the girls over the boys is in this case nearly that found in the present work.

120 Cattell, J., and Farrand, L., "Physical and Mental Measurements of the Students of Columbia University", *Psychol. Rev.*, vol. 3 (1896), pp. 618-648.

121 Woodworth, R. S., and Wells, F. L., "Association Tests", *Psych. Mon.*, vol. 13 (1911), p. 28.

122 Burt, C., "Experimental Tests of Higher Mental Processes and their Relation to General Intelligence", *Journ. of Exp. Ped. and Training Col. Record* (London), vol. 1 (1911), pp. 93-112.

Doll,[123] in experiments upon defective children (mental ages 3 to 11), found that the girls excelled in the "A-test" by 8 to 16 per cent.

(7) *Auditory Memory.*—The girls in every class show a superiority to the boys in memory for auditory digits, the excess on the average being 6.5 per cent.

(8) *Visual Memory.*—The girls here again, without exception in any group, are superior. The average of the girls' superiority (9.5 per cent) is greater here than in the case of auditory memory.[124]

(9) *Recognition.*—The girls excel the boys in this form of test—a relation which is found in all of the classes—on the average by 6.4 per cent.

The work of most of the other investigators of sex-differences in memory and recognition are in harmony with the results here obtained. Bolton[125], in tests upon a large number of grammar-school pupils from 10 years of age up, found that the probability of error in reproduction of numbers was less among the girls. For eight-place numbers the figures were:

	Probability of Error	
	Boys	Girls
Under 14 years	82.4	64.7
Over 14 years	65.4	65.8

The difference, according to these results, seems to be less as the age increases.

Kirkpatrick[126], in tests of visual and auditory memory for objects and words, found the following results:

[123] Doll, E. A., "The A-Test with the Feeble-Minded", *The Training School* (Vineland, New Jersey), vol. 10 (1913), pp. 49-57.

[124] It is interesting to note that among both boys and girls, the memory span for visual digits exceeds that for auditory digits. This is in agreement with the results obtained by most investigators.

[125] Bolton, T. L., "The Growth of Memory in School Children", *Amer. Journ. Psychol.*, vol. 4 (1892), pp. 362-380.

[126] Kirkpatrick, E. A., "An Experimental Study of Memory", *Psych. Rev.*, vol. 1 (1894), pp. 602-609.

	Primary School		Grammar School		High School		College		Avera[illegible]	
Sex	F.	M.	F.	M.	F.	M.	F.	M.	F.	[illegible]
Subject	15	15	39	47	58	53	50	102	162	[illegible]
No. reprod'ced	6.06	5.16	7.13	6.74	7.69	7.40	7.86	7.89	7.53	7

The same writer found also that the girls excelled in delay memory (3 days) for the same material.

Netschajeff[127] found that among girls the memory for wor and objects excelled that of the boys, especially of the ages fr 11 to 14 years. For memory of real objects, however, the bo were superior; and, moreover, the girls were more subject illusory errors.

Wissler[128] found in tests of 266 men and 42 women, freshm at Columbia University, that in memory for auditory digits t men averaged 7.6, the women 7.3. The men showed an avera span for visual digits of 6.9 as compared with 7.3 by the wome

Lobsien[129] found among school-children 9 to 14 years of a that in memory for real objects, for auditory digits, for soun and for tactual, visual, auditory, emotional and foreign term the girls generally, but not invariably, excel. His observati that the girls show a greater superiority in visual than in au tory memory is borne out by the present work.

Thompson[130] found that "there were more men than wom in whom auditory imagery was predominant, while women we more numerous in the visual and motor types" (p. 98), as shown in the following table:

		Predominant Auditory	Predominant Visual	Predominant Motor	Auditory Motor	Visu Mot
Auditory series	W.	4	9	3	7	1
	M.	13	5	2	3	2
Visual series	W.	1	10	6	2	4
	M.	8	8	2	1	2

127 Netschajeff, A., "Experimentelle Untersuchungen über d Gedächtnissentwickelung bei Schulkindern", *Zeitschrift für Psycholo und Physiologie der Sinnesorgane*, vol. 24 (1900), pp. 321-351.

128 Wissler, C., "The Correlation of Mental and Physical Test *Psych. Mon.*, vol. 3 (1901), no. 6, p. 62.

129 Lobsien, M., "Experimentelle Untersuchungen über die Gedäc nissentwickelung bei Schulkindern", *Ztsch. für Psychol. und Physi der Sinnesorgane*, vol. 27 (1901), pp. 34-76.

130 *Op. cit.*

The same writer also says: "In both the auditory and visual series the women show distinctly greater powers of memory" (p. 96). And later: "In memorization of nonsense syllables, the women memorize more rapidly than the men." "There is no difference between the men and women in retentiveness" (p. 99).

Schuyten[131] found in four different tests of memory for 2-place numbers, the following percentages of accuracy:

Girls	69.6	77.5	62.6	55.1
Boys	58.1	64.0	57.9	35.0
Percentile difference in favor of girls	11.5	13.3	4.7	20.1

Levy[132] found that in memory for words enclosed in geometric figures the women were superior to the men. The following are the scores for the various figures obtained by computation of the data given by that investigator:

	Women	Men
Triangle	17.7	16.6
Hexagon	17.2	16.9
Square	17.2	16.9
Circle	17.2	16.8
Diamond	17.1	16.8

In the average the women excel by about three per cent.

Summary.

(1) In addition and multiplication, the girls appear to be somewhat superior, although such is not invariably the case.

(2) In the drawing test, the girls appear to follow the method of emphasizing accuracy rather than speed; and the boys, speed rather than accuracy. That one sex is actually capable of excelling the other in either speed or accuracy cannot be said with certainty. Other investigations give conflicting testimony with regard to sex-differences in speed of movement; and with regard

131 Schuyten, M. C., "Sur les méthodes de mensuration de la fatigue des écoliers", *Archives de Psychologie*, vol. 4 (1904), pp. 113-128.

132 Levy, J. M., "Experiments on Attention and Memory with Special Reference to the Psychology of Advertising", *Univ. Calif. Publ. Psychol.*, vol. 2 (1916), no. 2, pp. 157 ff.

to accuracy, there is a small amount of evidence favoring the superiority of the boys.

(3) In the completion test the girls show a distinct superiority.

(4) The girls are decidedly more efficient in cancellation, according to the present and previous investigations.

(5) The girls excel without exception in memory for auditory and visual digits and in recognition of nonsense syllables. These results are in agreement with nearly all previous investigations.

(6) Excluding the tests for speed and accuracy of movement, in which the results, as far as ability is concerned, are uncertain, out of 42 comparisons (six classes in seven tests) the girls excel in 38 and the boys in 4.

General Summary and Conclusions

This investigation and the examination of data from other sources indicates a somewhat unsteady yet definite diurnal rhythm of efficiency for a variety of mental and physical functions. This is close to the conclusion arrived at by Marsh[133] when he expressed himself as "favorable to the idea of a few broad diurnal variations of a rather general nature, coexisting with more numerous and intensive variations in individuals." The dearth of intensive data, and the general lack of uniformity in the experimental conditions, made it impossible for this experimenter to find definite evidence of a general tendency common to all activities. "When", he says, "one attempts properly to weigh data obtained from diurnal periods in number from 2 to 24; from various measurements of various activities; from subjects of varying number, age, and sex; and under other varying conditions, the task is found to be quite hopeless."[134] In the present investigation such modifying factors and sources of error have been largely eliminated by a suitable method, and

[133] Marsh, *op. cit.*, p. 93. [134] *Ibid.*, p. 96.

by using as subjects a group of children of nearly the same age, doing nearly the same work, and with interests, environment, state of health, time of eating, of sleeping and of rising almost the same. And it has been found that the daily rhythm of efficiency is in most essentials the same for the various forms of mental and physical work.

The curve here found is characterized by a more or less steady rise from the first hour of the morning until midday. In the afternoon, the motor processes continue to increase in efficiency, while the more strictly mental functions show an after-lunch decrease, followed by a final increase in efficiency. In most respects the course of efficiency for both mental and motor functions is the same, while various other researches have indicated that pulse-rate, respiration, and other vital activities also follow the same course. It has been urged, moreover, that the rhythm of sleep is prolonged through the waking hours. This is most acutely felt, soon after rising, in a general drowsiness or sluggishness, which persists with ebb and flow during the day.

Apparently all forms of motor, mental, and vital activities are subject to a daily ebb and flow similar to the one we have found for mental activities in the case of school children. The organism appears to pass daily through a stage of "warming-up", or adaptation, which is facilitated by a number of factors, although such factors do, at the same time, have their opponents. The general belief seems to be that this adaptation is facilitated by internal and external sensory stimuli, acting cumulatively. Continued activity brings greater nervous irritability, a greater ease and dispatch of performance—in short, a greater efficiency for work. On a small scale we have something similar in the "warming-up" and "summation" phenomena of the nerve-muscle preparation of the frog.

Some[135] are of the opinion that this process of adaptation following a state of continued activity is alone responsible for variations in efficiency during the day, although many[136] believe

135 For instance, Hollingworth, *op. cit.*

136 See Marsh, *op. cit.*

that other factors, such as temperature, humidity, electrical and other changes are prominent factors. Of these, Hollingworth says,[137] "such influences, it would be exceedingly difficult to disentangle from many other factors", and "there is, indeed, no evidence that they exist." The present work, at least, gives us no reason to believe that such factors do not exist; indeed, it would seem reasonable to agree with Marsh, that although such factors may be isolated only with the greatest difficulty, they should not on that account be left out of court. But to what extent such factors are effective in determining efficiency, and to what extent the effect of the work process itself is involved, cannot at present be determined. As far as one is able to see, the two groups of influences work in harmony, and together are responsible for daily variations in efficiency.

The process of adaptation, however, can continue only to a certain point, when its course, by reason of opposing factors, is retarded. Prominent among such modifying factors is fatigue, which varies with the individual, the kind of work, and with various external conditions. Feelings of fatigue, loss of interest, and similar conditions have a similar effect. The time and heartiness of meals, drugs, and disturbances in internal and external conditions from other causes, also modify the course of efficiency.

The curves of efficiency for all forms of activity are in most respects alike; in fact, as far as the morning is concerned, they are identical. But with regard to the afternoon hours certain characteristic differences were found—differences, it seems reasonable to suppose, which are caused either by a difference in the form and nature of the process of adaptation or, what seems more likely, by a difference in the effectiveness in the assault of the various factors—fatigue, ennui, meals, etc.,—which have been mentioned, or by these combined with adaptation.

Whatever the causes may be, the fact is clear that those processes which are more strictly mental reach their maximum in the later forenoon, and show a great decrease following the

[137] Hollingworth, *op. cit.*, p. 473.

midday meal; while the functions whose elements are chiefly or wholly motor show a continuous increase in efficiency during the school day, with the maximum occurring in the last hour. Hollingworth[138] found a similar difference, of which he writes: "The influence of continued work upon more strictly mental processes differs characteristically from the effects upon processes essentially muscular in nature." In the present work the difference is most manifest in the hour following the midday meal; the mental processes show a decided drop at this hour, while the motor activities show an increase. Apparently the various factors which arise at the time of the midday meal, or which follow it, have less effect on the motor than on the mental functions. It is probable too, as Hollingworth has pointed out, that in the field of motor functions there is a more extended and more pronounced adaptation than in the field of the mental functions.

Midway between the curves of efficiency for the strictly mental functions and the strictly motor functions, lies the course of efficiency for larger muscular contractions and strength. The data from a large number of investigations (see p. 77) have generally agreed in showing an increase from a morning minimum to an afternoon maximum of efficiency similar to the curves found for the motor processes. The curves for gross muscular strength, however, generally show a temporary decrease following the midday meal, in which respect they resemble the curves for the strictly mental functions. This gives us a third form of variation in efficiency, and produces additional evidence that certain factors dependent upon the midday meal may cause, in some forms of activity, a drop in efficiency. Such factors have a very noticeable influence in the field of the strictly mental as well as of the gross muscular functions, while their effect is quite negligible upon such motor functions as have been here considered.

The present study indicates, moreover, that the purer the motor function, the more pronounced will be its difference from

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[138] *Op. cit.*, p. 491.

the course of the more strictly mental functions. The afternoon increase in speed of movement (maze test), for example, was double the increase in cancellation. The latter apparently was on the border between the motor and mental functions, and while it resembled the curve of the comparatively pure motor functions, it showed a tendency to partake of the nature of the other group. This relation was indicated also by the moderate correlation found between speed of movement and cancellation.

The facts brought out by the correlation of tests throw light on the diurnal variation, since they furnish additional evidence of a general ebb and flow of efficiency rather than of distinctive rhythms for specific functions. Except for the functions which were very closely related (multiplication and addition; auditory and visual memory), but small positive correlations were found —a fact which indicates that the tests which were used measured a variety of comparatively unrelated functions. The curves, then, for a number of such unrelated functions are very similar save, of course, for the difference between mental and motor functions, to which we have just alluded. The idea often held that different sorts of mental activities might have distinct daily variations is not in agreement with the results here obtained. These point rather to the existence of a few definite rhythms which are in many respects the same; a rhythm common to all mental functions; another common to most motor functions (maze test and cancellation test, etc.); and perhaps a third for gross muscular strength. For such functions as partake of the nature of two or more of these larger groups, the course of efficiency falls between the curves of the functions concerned.

The application of the results of this and other investigations will be left largely to the reader; mention will be made of a few inevitable suggestions only. First of all, it is clear that any trustworthy investigation must not disregard the existence of periodic changes in efficiency. Data which are to be compared cannot with safety be obtained at different times of the day on successive days unless some means of computing the

diurnal variations of efficiency are available. Similarly, in the investigation of fatigue or of phenomena which require continued or discontinuous work during the day, such periodicity in performance should not be left out of account.

Sex-differences have been computed with the result that the girls generally excel; but sex-differences with regard to the diurnal variations of efficiency have not been discovered. Although some investigators[139] have found slight differences in the time of maximum efficiency of the sexes among adults, others have not found such variations; and the present work indicates that marked sex-differences are not to be expected. At any rate, for practical purposes, it seemed best to take the sexes together in an attempt to discover the daily rhythm of efficiency for the reason that, at the present time at least, mixed classes are prevalent in the schools; and the results, if they are to be applied to such, should be based on the work of children of both sexes working together.

The results warrant no definite conclusions with regard to fatigue. To conclude, because of rapidly increasing efficiency, that pupils are not affected by fatigue at certain hours of the school day, would be unjustified for the reason that the efficiency shown at any hour is that of a mechanism in a certain stage of adaptation and at a certain stage of fatigue. Were no fatigue present, efficiency at any hour compared with that at the first hour of work might be quite different. In fact, the work of a host of investigators has shown that fatigue and feelings of fatigue, and the like, are, under certain conditions, quite sufficient to conceal the advantage one hour may otherwise have over another.

Since children engaged in the regular work of the school served as subjects in the present research and their efficiency was limited by such pure fatigue as existed, there is reason to believe that, in school work at least, much of the decrease in efficiency as the day wears on may be due to psychological rather than to physiological factors. Lack of interest, feel-

139 E. g., Marsh, *op. cit.*, p. 90.

ings of fatigue and the like, may cause the pupils to lessen their application to their work; and under such conditions as those in the present tests, where such feelings were largely eliminated, it is seen that the time which to casual observation may be the least efficient is really the time of greatest efficiency. It is probable that in the case of children any attempt to force an intense application to work at times when there is but slight inclination would be hazardous, in part because the pressure would be resented and would prove more harmful than the work itself. But in the case of adults a voluntary ordering of their lives is more clearly within the range of possibility. The feelings of fatigue and of ennui, which become more habitual and insistent as one indulges in them, might be made to disappear if one would work on in spite of them. Fortunately it appears that during some of the periods when we are most susceptible to such feelings of indisposition, the tendency to slacken in our work is counterbalanced by a high efficiency which then exists. To be able to avoid the disadvantages of the former and enjoy the advantages of the latter would be an end worth striving for. That one could, by effort, obtain the gain resulting from the disregard of the feelings of fatigue and the like, without suffering a loss due to various retarding factors, is a matter of great concern, but it lies beyond the field of the present work.

With regard to the arrangement of the school day, the data here presented have certain implications. From the results obtained by the more strictly mental tests, the advantage of a longer recess following the midday meal is indicated. The period of mental inefficiency persists until about 2 o'clock, and it would seem to be a wise move to arrange a two-hour recess before this time. Unfortunately we cannot be perfectly certain of the wisdom of such a change[140], for the present research does

[140] It is possible that the break in the period of work at midday, the habit of relaxing and resting at that time—quite apart from the mere physiological effects of the meal—allows the organism to revert from the state of high efficiency which existed in the late forenoon to a state of relatively low efficiency. Consequently it might well be that a certain amount of work must be accomplished to get the organism

not actually show that the hour from 3 to 4 P. M. is high in the scale of efficiency, although the trend of the curve during the hour preceding indicates this. Moreover, when the motor functions are considered, the 1 o'clock hour appears to be one of relatively great efficiency, since it is actually superior to the best of the forenoon hours. Such school work as drawing, writing, and other motor functions, apparently, could be given with advantage at this hour, and the advisability of shifting the afternoon session to a later hour would remain doubtful unless it could be demonstrated that the hour from 3 to 4 P. M. is of even greater efficiency for muscular work.

On the whole, the present work has confirmed the conclusions of Winch and others that difficult subjects may be handled as effectively in a later hour of the forenoon as at an earlier. It indicates further that in general the forenoon is the best time for strictly mental work, although the first morning hour is poor, while the afternoon may best be taken up with school subjects in which the motor factors are predominant. Yet it does not of necessity follow that the time of greatest performance is the time of greatest improvement. The time when one can work problems in arithmetic with the greatest speed and accuracy may not be the time when one will obtain the most lasting benefit from the work, or make the greatest advance. Indeed, the knowledge of the exact relationship of these conditions would be of great value. The work of Winch (p. 60 f.) has shown us that in the case of computation the time we have found most efficient for performance is also the time at which the pupils learn most rapidly. This would give some support to the thought that maximum performance comes at the time of maximum improvement.

The last word with regard to daily variations in efficiency has not, by any means, been spoken. The present findings can not with assurance be applied to conditions different from those

again "warmed up" and in the "swing for work", a process which might run the same course whether it were begun at 1 P. M. or 2 P. M. or later. For a discussion emphasizing the physiological effects of the meal especially, see Offner, *Mental Fatigue*, trans. by Whipple (1911), p. 86.

under which the investigation was conducted. The true character of daily rhythms in efficiency can be determined only by extensive investigations carried on at different places, under different environment, at different times of the year, and under different climatic conditions. If other investigations show that the same variations take place despite these different conditions, such knowledge will be of marked pedagogical significance.

Transmitted September 12, 1914.

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EXPERIMENTS ON ATTENTION AND MEMORY, WITH SPECIAL REFERENCE TO THE PSYCHOLOGY OF ADVERTISING

BY

J. M. LEVY

UNIVERSITY OF CALIFORNIA PRESS
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J. M. LEVY

CONTENTS

Part I

The Attention Value of Positions on the Eight-Sheet Billboard

Part II

The Value for Attention and for Memory of Certain Variations of Form, Size, and Duration of a Seen Object

PART I

THE ATTENTION VALUE OF POSITIONS ON THE EIGHT-SHEET BILLBOARD

Section 1: Experiments Without Predetermined Fixation

The entire problem of attention, of which this paper treats, is of importance to the advertiser, and an understanding of it is necessary for the wisest application of advertising.

Of the various media of publicity used in modern advertising the present study is concerned with that form of outdoor publicity known as the bill-board, and especially with a definite unit of that system, the eight-sheet stand.

This form is composed of eight one-sheet units, each measuring 28 inches high by 42 inches wide, the total area of the eight sheets being 9 feet 4 inches in height by 7 feet in width. Each one-sheet unit, because of its position in the visual field, has a definite attention value. Our problem resolves itself into a determination of a preference point, or of the distribution of attention over the area in question.

The plan of the experiment here reported involved a series of tests with and without the introduction of a fixation point on boards, at, above, and below the level of the eyes, and involved also minor considerations which will be explained during the progress of the report.

The practical difficulty of dealing with the full-size billboard required its reproduction in reduced dimensions, which still preserved the visual angle and proportions of the original.

In the first part of the experiment (in which five observers were used), the observer was seated within a darkened enclosure, having an opening through which he observed a white screen 73 cm. high by 57 cm. wide—the proportion of the bill-board. The center of the screen was placed in line with the primary position of regard, 4 meters distant, in a room darkened sufficiently to make the screen only faintly visible.

An exposure wheel with an aperture of 0.4° cut radially, which gave an exposure of about 1.6σ was used in connection with a projection lantern and lantern slides made for the purpose of the experiment. The slides were marked in such a manner that when projected on the screen, the area of the miniature bill-board was divided into eight equal parts, of dimensions corresponding to the one-sheet units, seven of which contained

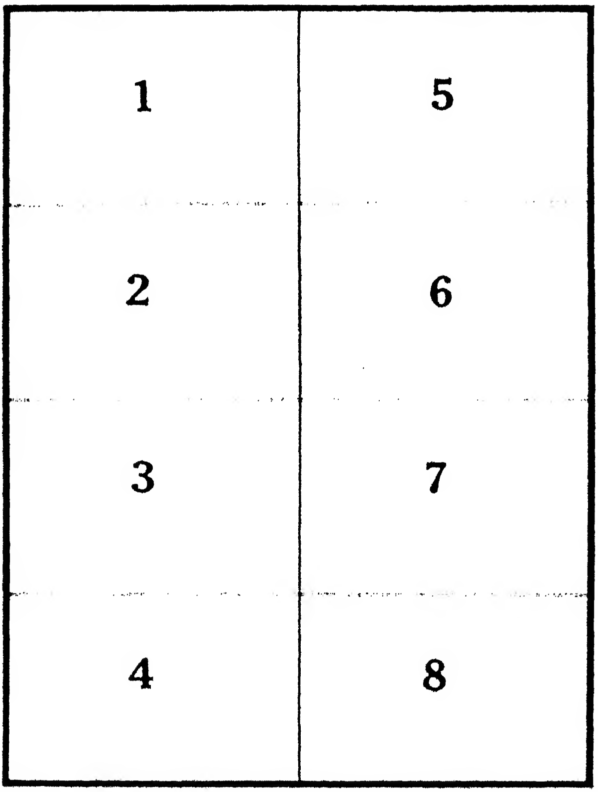

Fig. 1

each a black cross, one remaining blank. The location of the blank varied in each slide; thus eight different positions were assumed by the blank during the course of the experiment.

Each space-unit had a position name, as indicated in Figure

TABLE I

Judgments for Different Positions on the Billboard
Chance Order

1

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	27	15	2	4	25	17	20	9
K	22	10	2	2	10	9	12	5
J	21	9	3	2	3	4	6	5
H	27	1		1	7	2	2	
B	25	9	1		9	6	4	
	122	44	8	9	54	38	44	19

Total Judgments, 338.
Correct Judgments, 122, or 36%.

5

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	10	5	3	4	46	18	10	6
K	12	8	3	9	28	10	3	6
J	3	5	2	5	20	8	8	2
H	4	5		5	20	11	4	2
B	3	1	1	2	27	10	3	1
	32	24	9	25	141	57	28	17

Total Judgments, 333.
Correct Judgments, 141, or 42%.

2

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	13	71	7	1	14	13	6	4
K	14	49	5	2	3	7	6	
J	11	15	3	4	4	9	7	6
H	1	34	2	1			1	1
B	11	26	6	2	3	5	5	4
	50	195	23	10	24	34	25	15

Total Judgments, 376.
Correct Judgments, 195, or 52%.

6

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	5	12	5	4	20	37	10	9
K	4	15	6		10	43		2
J	9	9	3	4	7	17	10	10
H	1	3	3	1	8	19	3	
B	7	9	6	2	10	12	4	2
	26	48	23	11	55	128	27	23

Total Judgments, 341.
Correct Judgments, 128, or 37%.

3

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	3	8	54	3	10	6	11	10
K	2	7	53	3	8	1	7	2
J	7	10	24	3	4	7	8	
H			30	2	2	3	1	1
B	3	6	25	4	2	7	13	1
	15	31	186	15	26	24	40	14

Total Judgments. 351.
Correct Judgments. 186, or 53%.

7

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	2	4	2	3	12	21	54	10
K	2	1	1	1	1	10	70	1
J	1	2	3	1	3	14	32	5
H	1			1	2	6	32	
B	9	3	5	3	10	7	18	3
	15	10	11	9	28	58	206	19

Total Judgments, 356.
Correct Judgments, 206, or 58%.

4

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	6	10	4	51	11	8	2	1
K	2	2	6	57	2	1	4	1
J	2	3	8	29	4	1	1	1
H		2	2	28	1	3	1	1
B	2	9	7	14	7	8	2	1
	12	26	27	179	25	21	10	5

Total Judgments, 305.
Correct Judgments, 179, or 59%.

8

	JUDGMENTS							
	1	2	3	4	5	6	7	8
N	7	6	4	3	8	8	6	57
K	1	2	1	6	1		3	49
J	2	5	6	3	1	1	10	20
H		3	5	1	1	3	3	23
B	8	12	4	3	1	6	10	11
	18	28	20	16	12	18	32	160

Total Judgments, 304.
Correct Judgments, 160, or 53%.

1; beginning at the top and left was No. 1, followed immediately below by Nos. 2, 3, and 4; at the top and right was No. 5, then 6, 7, and 8. And it was the duty of the observer to locate the blank by its appearance in one of the above positions. The correct judgments determined the relative attention-value of the different space positions.

The observer's expectant attention was secured by the two commands "ready" and "now", the first given two seconds before the stimulus. Whenever an alteration or an indecision of judgment occurred, that slide was replaced by another. Only definite judgments were recorded.

The first method of exposure was that of a chance order of presentation, and Table I, page 160, gives the judgments of the five observers.[1]

From this table it may be concluded that the relative value of the various positions as indicated by the correctness of locating the blank is as follows:

	Position name.*
Highest Value	4
	7
	8
	3
	2
	5
	6
Lowest Value	1

*See diagram, page 159.

Other systems of exposure.—The question whether the recognition of the position of the blank was influenced by the preceding exposures formed the motive for the following series of experiments:

[1] In the accompanying tables the actual location of the "blank" will be indicated by the bold-faced numeral beside the group of judgments. Heading the columns in each particular group there appear the position names, and under these appear the judgments which assigned the blank to that position.

System 1–2–2–1: The blank exposed in position 1 followed by its exposure in position 2—then reverse order, blank exposed in position 1. Blank exposed in position 2 followed by its exposure in position 3—then blank exposed in position 3 followed by position 2, thus continuing through the remaining combinations.

System 1–5–5–1: The blank exposed in position 1 followed by its exposure in position 5—then reverse order, blank exposed in position 5 followed by its exposure in position 1. Blank exposed in position 2 followed by its exposure in position 6—then blank exposed in position 6 followed by position 2, thus continuing through the remaining combinations.

The positive primary image by which the blank was principally recognized persisted for too small an interval to remain in any memory process for comparison with the succeeding blank. The intervals between the exposures (about twenty seconds) were of such a duration that no persistence of any after image of the preceding exposure was observed. We may therefore assume from the following data that there was no sensory fusion or any sensory illusions.

From Table II we may conclude that by this system (1–2–2–1 order) the relative attention values of the various positions in order as indicated by the frequency of correct judgments is:

	Position Name
Highest Value	7
	3
	4
	8
	2
	6
	5
Lowest Value	1

TABLE II

Judgments for Different Positions on the Billboard
Order 1–2–2–1

1

	JUDGMENTS 1	2	3	4	5	6	7	8
N	1			1	5	2	1	2
K	3	1		1	2	4	3	1
J	3	3		1	1		1	1
H	5					1		
B	1	2			3	1	1	
	13	6		3	11	8	6	4

Total Judgments, 51.
Correct Judgments, 13, or 26%.

2

	JUDGMENTS 1	2	3	4	5	6	7	8
N	6	7	1		3	6		1
K	8	14	2	1	1		1	
J	5	2	2	1		4	2	4
H		13						
B	4	6	1	1			3	1
	23	42	6	3	4	10	6	6

Total Judgments, 100.
Correct Judgments, 42, or 42%.

3

	JUDGMENTS 1	2	3	4	5	6	7	8
N	2	2	9		2	1	4	2
K		1	16					
J	4	4	6	1	1	3	1	
H			10	1	1	1		
B	2	2	5	4		1	2	
	8	9	46	6	4	6	7	2

Total Judgments, 88.
Correct Judgments, 46, or 52%.

4

	JUDGMENTS 1	2	3	4	5	6	7	8
N		1	1	5	1	1	1	
K	1		1	10	1		1	
J			3	6	1			
H				3		3		
B	1	1		1	2	2	1	
	2	2	5	25	5	6	3	

Total Judgments, 48.
Correct Judgments, 25, or 52%.

5

	JUDGMENTS 1	2	3	4	5	6	7	8
N	2		1		4	2		1
K	4	2			3	2	1	2
J	1		1		2	3	2	1
H				2	3			1
B	1				5	2		
	8	2	2	2	17	9	3	5

Total Judgments, 48.
Correct Judgments, 17, or 35%.

6

	JUDGMENTS 1	2	3	4	5	6	7	8
N	2	1	1	2	4	6		4
K	1	6	3		3	10	1	1
J	3	1	1	2	3	9	1	
H		2	1		5	3	1	
B	3	3			4	5	1	
	9	13	6	4	19	33	4	5

Total Judgments, 93.
Correct Judgments, 33, or 36%.

7

	JUDGMENTS 1	2	3	4	5	6	7	8
N			1		4	4	7	4
K	1	1				2	20	
J		1	2			6	10	1
H						2	10	
B	2	2	1	1	4	1	4	1
	3	4	4	1	8	15	51	6

Total Judgments, 92.
Correct Judgments, 51, or 55%.

8

	JUDGMENTS 1	2	3	4	5	6	7	8
N	2	1					1	6
K				3				9
J	3	1	2			1	2	1
H			1	1				4
B		1	2		1	1	1	2
	5	3	5	4	1	2	4	22

Total Judgments, 46.
Correct Judgments, 22, or 48%.

TABLE III

Judgments for Different Positions on the Billboard
Order 1 5 5 1

1

JUDGMENTS

	1	2	3	4	5	6	7	8
N	2			1	3	2	0	4
K	3	6		1		1	1	
J	3			1	1	2	1	
H	4	1			1			
B	2	2			1		1	
	14	9		3	6	5	3	4

Total Judgments, 44.
Correct Judgments, 14, or 32%.

5

JUDGMENTS

	1	2	3	4	5	6	7	8
N	3	1			6		2	
K	2	1		3	3	1	1	1
J		1		1	1		1	1
H		1			2	3		
B				1	3	1	1	
	5	4		[illegible]	18	[illegible]	[illegible]	2

Total Judgments, 44.
Correct Judgments, 18, or 41[illegible]

2

JUDGMENTS

	1	2	3	4	5	6	7	8
N.		9	1			1		1
K	3	3	1		2	1	1	
J		4	1	1	1	2		
H		3						
B		4	1		1			
	3	23	4	1	4	4	1	1

Total Judgments, 41.
Correct Judgments, 23, or 56%.

6

JUDGMENTS

	1	2	3	4	5	6	7	8
N	1	1	1	1	2	3	[illegible]	1
K	1	2	1		2	4		1
J		3	1			2	1	1
H		2				2		
B	1		3		2			
	3	8	6	1	6	11	[illegible]	[illegible]

Total Judgments, 41
Correct Judgments, 11, or [illegible]%.

3

JUDGMENTS

	1	2	3	4	5	6	7	8
N		1	7		1		2	1
K	1	2	6	1				
J		2	2	1	1		2	
H			2		1	1	1	1
B			3		1	1	1	
	1	5	20	2	4	2	6	2

Total Judgments, 42.
Correct Judgments, 20 or 48%.

7

JUDGMENTS

	1	2	3	4	5	6	7	8
N	1		1	1	2	1	[illegible]	1
K						2	8	
J				1		1	4	2
H	1			1		1	2	
B					1	4	1	
	2		1	3	3	[illegible]	20	[illegible]

Total Judgments, 41
Correct Judgments, 20, or 4[illegible]

4

JUDGMENTS

	1	2	3	4	5	6	7	8
N				9	1			
K			2	6		1		
J		1	1	6				
H				4	1			1
B		3	1	1		1		
		4	4	26	2	2		1

Total Judgments, 39.
Correct Judgments, 26, or 67%.

8

JUDGMENTS

	1	2	3	4	5	6	7	8
N						1	1	[illegible]
K		1		1				[illegible]
J			1		1		[illegible]	2
H		1					1	4
B	2	2				1		1
	2	4	1	1	1	[illegible]	[illegible]	[illegible]

Total Judgments, [illegible]
Correct Judgments, [illegible], or [illegible].

From Table III, we may conclude that by this system (1-5-5-1 order) the relative attention values of the various positions as indicated by their frequency of correct judgments is:

	Position Name
Highest Value	4
	8
	2
	7
	3
	5
	1
Lowest Value	6

The following condensed Table IV (p. 167) gives a recapitulation of the percentage of correct judgments for the three systems, and also the first and second "substitute" positions—that is, the positions most frequently chosen in the incorrect judgments for each system.

Computing the proportionate number of correct judgments to the total received, we have the following average percentage of correct judgments for each system and their general average for the upper half and the lower half of the bill-board.

		Upper half (Nos. 1, 2, 5, 6)
Chance order	42%	General Average 39%
1-5-5-1 system	39%	
1-2-2-1 system	36%	

		Lower half (Nos. 3, 4, 7, 8)
Chance order	55%	General Average 54%
1-5-5-1 system	55%	
1-2-2-1 system	53%	

There is consequently a marked tendency of attention toward the lower half of the screen.

Computing as above the average percentages of correct judgments for each system and their general average, for the left half and right half of the bill-board, they are as follows:

		Left half (Nos. 1, 2, 3, 4)
Chance order	50%	General Average 48%
1-5-5-1 system	50%	
1-2-2-1 system	44%	

		Right half (Nos. 5, 6, 7, 8)
Chance order	48%	General Average 45%
1-5-5-1 system	44%	
1-2-2-1 system	44%	

Thus the two vertical halves with a three-per-cent difference are more nearly equal than are the top and bottom halves with a fifteen-per-cent difference; the left half, however, receives slightly more attention than does the right.

The results do not indicate any influence from the preceding position of the blank. On the average, there is, however, a consistent tendency to attend to the left half of the screen more than to the right; and to the lower half, than to the upper. Positions 1, 5, and 6 are, in value, uniformly near the bottom of the list; while position 4 is uniformly at or near the top.

Section 2: Experiments With Fixation Point (The Eye in Primary Position)

The second part of the experiment consisted in an attempt to note what would be the influence of a fixation point upon the relative attention value of the various position units of the bill-board, (*a*) when the center of the bill-board is so placed that the eye in fixating it is in its primary position as before; (*b*) when the bill-board assumes a position above or below this.

Method.—Six observers were used, four of whom had had experience in the first part of the experiment. The observer was seated in a dark chamber wherein the screens were exposed. Three screens, each having the dimensions used in the previous part of the experiment, were placed directly above one another; the middle screen, whose center was in the primary line of regard, was three meters distant from the observer, the angle of vision being 14°. The centers of the lower and upper screens

TABLE IV

Recapitulation of Exposure Methods

1

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	36%		5	2
1551	32%	34%	2	5
1221	26%		5	6

2

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	52%		1	6
1551	56%	50%	3	6
1221	42%		1	6

3

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	53%		7	2
1551	48%	51%	7	2
1221	52%		2	1

4

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	59%		3	2
1551	67%	59%	3	2
1221	52%		6	3

5

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	42%		6	1
1551	41%	39%	1	7
1221	35%		6	1

6

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	37%		5	2
1551	27%	33%	2	5
1221	36%		5	2

7

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	58%		6	5
1551	49%	54%	6	5
1221	55%		6	5

8

	JUDGMENTS			
	Correct		Substitutes	
		Average	1st	2nd
Chance	53%		7	2
1551	60%	53%	7	2
1221	48%		1	3

were each 78 cm. distant from the center of the middle screen, the respective visual angles being 13°, while an angle of 21° subtended the 114 cm. distance between the center of the middle screen and extreme upper and lower edgė of top and bottom screen respectively. A permanent fixation point was formed by a small and very dim glow-light exposed from behind through the center of the middle screen. Coming from the same lighting system, the fixation point and the illuminated area of the screen had a constant relative intensity.

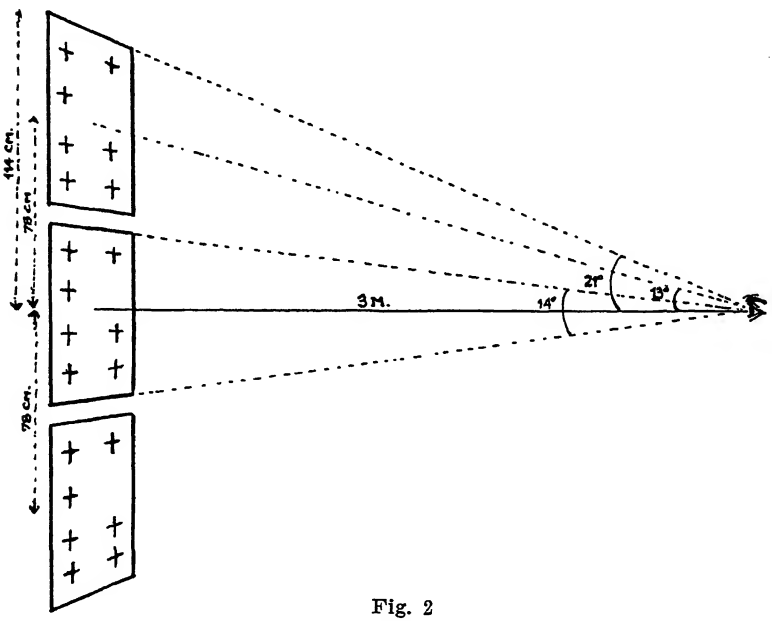

Fig. 2

The screens were invisible in the complete darkness of the room, and the same apparatus was used as in the earlier experiments. After retinal adaptation to darkness to such a degree that the dim fixation point became visible, a series of judgments for each level was secured separately, so that there was an "associated expectancy" of the special relation of the exposure to the fixation point.

The observers were cautioned throughout the experiment to maintain a steady fixation when the signal was given. However, it is probable that occasionally there was unconscious movement of the eyes.

A greater effort of the will, to maintain the desired attention, was necessary here and a greater strain resulted than in any other part of the experiment.

The same procedure of exposure was maintained as in the first part of the experiment. An interpretation of the following tables will give an indication of the attention value of the different positions on the upper and lower screen as compared with those on the middle screen, while the fixation point continued at the primary position.

Commencing with the lower screen (see Table V), the attention values of the positions by reason of their average percentage of correct judgments follow:

	Position Name
Highest Value	2
	5
	1
	8
	7
	6
	3
Lowest Value	4

The first three fall within the top half of the screen, the area nearest to the fixation point, and closer to the center of vision. The judgments of the right and left halves of the screen indicate nothing worthy of comment.

The attention values for positions on the middle screen (see Table VI) are:

	Position Name
Highest Value	3
	2
	7
	8
	4
	1
	6
Lowest Value	5

TABLE V

Judgments for Different Positions on the Billboard
Lower Level
Fixation Point 78 Cm. Above

1

	JUDGMENTS 1	2	3	4	5	6	7	8
N	6	1		1	3	1		
K	6	1			1	2		
V	22	2	1					2
B	4		1		5	1	1	
H	17	1	2		1			
	55	5	4	1	10	4	1	2

Total Judgments, 82.
Correct Judgments, 55, or 67%.

5

	JUDGMENTS 1	2	3	4	5	6	7	8
N	1				6	5		
K	1				7	1		
V	1				22	1	5	2
B	2	1	1		3			
H					17	2	2	
	5	1	1		55	9	7	2

Total Judgments, 80.
Correct Judgments, 55, or 69%.

2

	JUDGMENTS 1	2	3	4	5	6	7	8
N		8	2			3		
K		10	2					
V	1	26	4			1	1	1
B	1	4	1	1	1	2	2	
H		17	3				1	
	2	65	12	1	1	6	4	1

Total Judgments, 92.
Correct Judgments, 65, or 70%.

6

	JUDGMENTS 1	2	3	4	5	6	7	8
N	1			1	5	4	2	1
K	1				5	2		1
V			2	1	4	13	5	4
B	1	1		1	7	2	2	
H			1	2		11	4	4
	3	1	3	5	21	32	13	10

Total Judgments, 88.
Correct Judgments, 32, or 36%.

3

	JUDGMENTS 1	2	3	4	5	6	7	8
N	2	1	1		2		5	1
K	2		4	1		1	2	
V		2	13	11	1		2	3
B	2		4		3	1		1
H		1	8	4	2		5	2
	6	4	30	16	8	2	14	7

Total Judgments, 87.
Correct Judgments, 30, or 35%.

7

	JUDGMENTS 1	2	3	4	5	6	7	8
N					2	6	5	1
K	1	2			2	1	3	3
V	1	1		1		4	11	9
B	1	1	4		3	4	1	
H	1			1	2	2	14	1
	4	4	4	2	9	17	34	14

Total Judgments, 88.
Correct Judgments, 34, or 39%.

4

	JUDGMENTS 1	2	3	4	5	6	7	8
N	4			1		1	4	5
K	4	1	1	3	2	1	1	
V	1	3	3	7		2	2	11
B	2	2			2	4		
H		1	4	8	2	1	4	3
	11	7	8	19	6	9	11	19

Total Judgments, 90.
Correct Judgments, 19, or 21%.

8

	JUDGMENTS 1	2	3	4	5	6	7	8
N	1	1			3	1	4	5
K	2		2	1	2	1		5
V				1	1	1	3	22
B	1	3	2	2	1	2	3	
H	1	1		2	1		10	6
	5	5	4	6	8	5	20	38

Total Judgments, 91.
Correct Judgments, 38, or 42%.

TABLE VI

Judgments for Different Positions on the Billboard
Middle Level
Fixation Point Center of Screen

1

JUDGMENTS

	1	2	3	4	5	6	7	8
H	15					1	1	
N	10				1		2	2
F	20	1			1			
B	11	2	1	1	4	1		1
K	16	1						
V	18	2				1		
	90	6	1	1	6	3	3	3

Total Judgments, 113.
Correct Judgments, 90, or 80%.

2

JUDGMENTS

	1	2	3	4	5	6	7	8
H		17						
N	2	9	1	1			1	
F		23				1		
B	3	14				3	2	
K		14						
V		21						
	5	98	1	1		4	3	

Total Judgments, 112.
Correct Judgments, 98, or 88%.

3

JUDGMENTS

	1	2	3	4	5	6	7	8
H			15				1	
N			14					
F			22					
B		2	12		2	1	3	
K			17					
V			17		1	1		
		2	97		3	2	4	

Total Judgments, 108.
Correct Judgments, 97, or 90%.

4

JUDGMENTS

	1	2	3	4	5	6	7	8
H				18				
N			1	11			2	2
F				22				
B	1	2	2	13	1	5		
K	1			20				
V				20				
	2	2	3	104	1	5	2	2

Total Judgments, 121.
Correct Judgments, 104, or 86%.

5

JUDGMENTS

	1	2	3	4	5	6	7	8
H					15	2	1	1
N					9		2	3
F		3	1		13	6	1	
B	1			1	12	4	2	
K	1	1			18	4		
V		2		1	13	1		1
	2	6	1	2	80	17	6	5

Total Judgments, 119.
Correct Judgments, 80, or 67%.

6

JUDGMENTS

	1	2	3	4	5	6	7	8
H						16	1	1
N	1		2		2	1	3	3
F			1		1	20	1	
B		3	1		4	11	5	1
K	1	1				15		
V					2	16		1
	2	4	4		9	79	10	6

Total Judgments, 114.
Correct Judgments, 79, or 70%.

7

JUDGMENTS

	1	2	3	4	5	6	7	8
H						1	15	
N	1	1	1		1	2	10	
F		1					23	
B	1		2		1		13	1
K							15	
V							19	
	2	2	3		2	3	95	1

Total Judgments, 108.
Correct Judgments, 95, or 88%.

8

JUDGMENTS

	1	2	3	4	5	6	7	8
H							1	14
N				1			1	16
F								21
B	1	1	2		2		3	9
K								16
V						1		16
	1	1	2	1	2	1	5	92

Total Judgments, 105.
Correct Judgments, 92, or 88%.

It is of interest to note that the first three positions fall in the immediate area of the fixation point, two of which are on the left half and one on the right half of the screen. The two lowest positions, No. 8 and No. 4, have a greater attention value than the two at the top, No. 1 and No. 5, and rank ahead of No. 6 which is nearer the fixation point. These results are in agreement with those of the first part of the experiment where a fixation point was not used.

The attention values for positions on the upper screen (see Table VII) are:

	Position Name
Highest Value	3
	4
	8
	2
	7
	6
	5
Lowest Value	1

The first three positions fall within the lower half of the screen, and in the area nearest the fixation point.

The results establish the fact that the average of incorrect judgments in the upper and lower screens were in the positions farthest from the fixation point and located in the peripheral region of the retina.

The average percentage of correct judgments for positions on the three screens is, for the lower, 47 per cent; for the middle, 83 per cent; and for the upper, 38 per cent.

From this part of the experiment, we may infer that the judgments on the lower screen are 10 per cent more favorable for accuracy than the positions on the upper screen, and that the middle screen is 36 per cent more accurate than the lower and 45 per cent more than the upper screen.

Comparing the values of the middle screen containing the fixation point with the same area described in Part I without the fixation point, we find a greater percentage of correct judgments for each half with the fixation point, due possibly to the

TABLE VII

Judgments for Different Positions on the Billboard
Upper Level
Fixation Point 78 Cm. Below

1

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F	4	3	1	2		3	2	5
K	4	3	2	5	1	2		
N	2	1		2			1	2
B	3	3	4	4	2		3	5
V	2	3	1	1	2	1	2	11
H	2		1			1	1	2
	17	13	9	14	5	7	9	25

Total Judgments, 99.
Correct Judgments, 17, or 17%.

5

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F		7	1	1	4	10	2	2
K		2	1	4	3	1	4	1
N				1	6		1	2
B	9	4	3		2	1	5	
V	7	3		2	6			11
H	1	1				2	3	
	17	17	5	8	21	14	15	16

Total Judgments, 113.
Correct Judgments, 21, or 19%.

2

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F	1	18		1	1	1		
K	2	4		4	2			3
N	1	4	1					1
B	7	3	3	5	3	2	1	2
V	1	6	5	4	2	2	1	4
H	1	2	3					
	13	37	12	14	8	5	2	10

Total Judgments, 101.
Correct Judgments, 37, or 37%.

6

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F	1		1		3	12	5	
K		2	2	4	1	3	1	4
N			1	1	1	3		1
B	6	3	3		3	7	2	2
V		1	2	3	2	4	5	10
H						4	1	
	7	6	9	8	10	33	14	17

Total Judgments, 104.
Correct Judgments, 33, or 32%.

3

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F		1	15	1			1	
K	1	1	9	1				4
N		2	6	1			1	
B	2	1	5	4	3	2	3	2
V	3	6	13	2		2		2
H			6					
	6	11	54	9	3	4	5	8

Total Judgments, 100.
Correct Judgments, 54, or 54%.

7

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F			1	1		5	11	4
K	1	1	2	2	1	3	5	2
N					1	2	2	2
B	3	7	2	1	2	2	3	1
V	1	3	1	4		1	10	2
H						2	8	
	5	11	6	8	4	15	39	11

Total Judgments, 99.
Correct Judgments, 39, or 40%.

4

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F		3	3	18		1		2
K	1	2	2	11				
N				7				1
B	1	4	3	5	2	3	2	1
V	1	4	3	10	4		2	3
H	1		1	5				
	4	13	12	56	6	4	4	7

Total Judgments, 106.
Correct Judgments, 56, or 53%.

8

	JUDGMENTS							
	1	2	3	4	5	6	7	8
F				1			1	17
K				1	1		5	9
N	2			2	1			3
B	1	3	3	1	2	5	2	8
V			2		1			17
H	2						3	2
	5	3	5	5	5	5	11	56

Total Judgments, 95.
Correct Judgments, 56, or 59%.

TABLE VIII

Recapitulation of Various Levels

	Screen Levels	Correct Judgment	1st Substitute	Screen Levels	Correct Judgment	1st Substitute	
1	Lower	67%	5	Lower	69%	6	5
	Middle	80%	2	Middle	67%	6	
	Upper	17%	8	Upper	19%	1	
	Screen Levels	Correct Judgment	1st Substitute	Screen Levels	Correct Judgment	1st Substitute	
2	Lower	70%	3	Lower	36%	5	6
	Middle	88%	1	Middle	70%	5	
	Upper	37%	1	Upper	32%	8	
	Screen Levels	Correct Judgment	1st Substitute	Screen Levels	Correct Judgment	1st Substitute	
3	Lower	35%	4	Lower	39%	6	7
	Middle	90%	7	Middle	88%	6	
	Upper	54%	2	Upper	40%	6	
	Screen Levels	Correct Judgment	1st Substitute	Screen Levels	Correct Judgment	1st Substitute	
4	Lower	21%	8	Lower	42%	7	8
	Middle	86%	3	Middle	88%	7	
	Upper	53%	3	Upper	59%	7	

effect of practice, but more especially to the presence of a fixation point. The presence of the fixation point probably accounts also for the smaller difference between the number of correct judgments for the upper and the number for the lower half of the screen.

The results further imply a greater attention value for the lower half of the field.

Section 3: Experiments With Fixation Point Giving a Position of the Eye at or Above Its Primary Position

The following experiments were conducted with and without a fixation point in each screen-position.

Because of the practical conditions in the field of advertising,[2] only the upper and middle screen levels of Part II were used in this part of the experiment. Otherwise the same procedure was followed as in the second part of the experiment.

The accompanying Tables (Nos. IX and X) will give an indication of the attention value of the different positions on the upper and middle screens when a fixation point is and is not present.

For the upper screen the attention values follow:

With fixation point Position Number		Without fixation point Position Number
3	Highest Value	8
8		3
2		2
4		1
1		4
7		7
6		6
5	Lowest Value	5

It is worthy of notice that the attention values of half the positions with and without the fixation point have exactly the same rank, and that there is simply a reversal of order for the

[2] Billboards consist of 2 "decks"—the lower on a level with the eye, and upper, superposed, averaging 10 feet above the street.

TABLE IX

Judgments for Different Positions on the Billboard
Upper Level
Fixation Point in Center of Screen

1

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	6	2	2		5	1	3	
F	19	1			3	1	1	1
H	20					1		
K	16	1			1	2	2	
N	6	1			1	1		
V	18				2	1		
	85	5	2		12	7	6	1

Total Judgments, 118.
Correct Judgments, 85, or 72%.

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	3	1	1	2	4	6		2
F			1		12	2	8	1
H					17	6	7	
K	2	4	3		9			1
N	2	2	1	2	1	1		1
V		2			11	5	1	1
	7	9	6	4	54	20	16	6

Total Judgments, 124.
Correct Judgments, 54, or 44%.

2

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	2	10	3		1	1	3	
F		15			1	1	1	1
H		25						
K	2	19	3			1		
N		8		1				
V		19				3	1	
	4	96	6	1	2	6	5	1

Total Judgments, 121.
Correct Judgments, 96, or 80%.

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B		3	3		2	5	1	1
F			1		4	14	3	
H				1		15	4	
K		3		2	2	15		
N	1	1	1		4	1	1	
V	2	1			3	12		1
	3	8	5	3	15	62	9	2

Total Judgments, 107.
Correct Judgments, 62, or 58%.

3

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	2	2	13					
F		1	23					
H			19				1	
K	1		16			1		1
N			10					
V	2		17			1		
	5	3	98			2	1	1

Total Judgments, 110.
Correct Judgments, 98, or 89%.

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	2	1	1		4	2	8	1
F					2	2	14	2
H	1		1		1		15	
K	1		2			1	19	
N					1	3	5	
V	1				1	3	14	
	5	1	4		9	11	75	3

Total Judgments, 108.
Correct Judgments, 75, or 70%.

4

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	2	3	2	3	3	2	3	
F				21	1			
H				21			1	
K		1	2	19				
N	1			8				
V		1		21	1		1	
	3	5	4	93	5	2	5	

Total Judgments, 117.
Correct Judgments, 93, or 80%.

	JUDGMENTS							
	1	2	3	4	5	6	7	8
B	1	1	1		3	2	2	10
F				1			1	18
H							2	20
K								21
N					2			5
V			1			2		16
	1	1	2	1	5	4	5	90

Total Judgments, 109.
Correct Judgments, 90, or 83%.

TABLE X

Judgments for Different Positions on the Billboard
Upper Level
No Fixation Point

1

JUDGMENTS

	1	2	3	4	5	6	7	8
B	7	1	2	1	3	3	2	
F	12	2			5	1	2	
H	19	1			3	1		
K	15	2			2		2	
N	8	2				1		
V	13	1		1	5	3		
	74	9	2	2	18	9	6	

Total Judgments, 120.
Correct Judgments, 74, or 62%.

5

JUDGMENTS

	1	2	3	4	5	6	7	8
B	4	2	1	2	6	3	1	1
F	1	1		2	8	3	6	3
H					17	4	3	
K	2	2		2	8	1	2	3
N	1	1	1		3		1	2
V	4	1	1		7	3	4	2
	12	7	3	6	49	14	17	11

Total Judgments, 119.
Correct Judgments, 49, or 41%.

2

JUDGMENTS

	1	2	3	4	5	6	7	8
B	2	7	1		1	3	2	5
F	1	14	1			2	1	2
H		23						
K	5	9	1			1	2	
N		8			1	1		
V	2	18		1	3			1
	10	79	3	1	5	7	5	8

Total Judgments, 118.
Correct Judgments, 79, or 67%.

6

JUDGMENTS

	1	2	3	4	5	6	7	8
B	3	2	1		3	7	2	1
F		1	3	1	4	13	1	
H					3	17	4	
K	1	2	3		2	12		2
N					6	6	1	1
V	1		2		3	11	3	2
	5	5	9	1	21	66	11	6

Total Judgments, 124.
Correct Judgments, 66, or 53%.

3

JUDGMENTS

	1	2	3	4	5	6	7	8
B		1	14	1	1		3	1
F			21			1		
H		4	16	1		1	1	1
K		2	14	1			1	1
N			14	1				
V		1	18	1	1	1		
		8	97	5	2	3	5	3

Total Judgments, 123.
Correct Judgments, 97, or 80%.

7

JUDGMENTS

	1	2	3	4	5	6	7	8
B	3	2	1	1	2	2	6	1
F		1	1	1		3	15	2
H		1		1	2	3	15	1
K	1		3	1	1		15	1
N			1		1	1	7	
V			2	1	2	2	10	2
	4	4	8	5	8	11	68	7

Total Judgments, 115.
Correct Judgments, 68, or 59%.

4

JUDGMENTS

	1	2	3	4	5	6	7	8
B	4	3	4	3	4	2		
F	1	1	1	14				
H				20	1		1	1
K			3	11	1	2	1	2
N		1	1	6	2		1	1
V	2	2		16			1	
	7	7	9	70	8	4	4	4

Total Judgments, 113.
Correct Judgments, 70, or 62%.

8

JUDGMENTS

	1	2	3	4	5	6	7	8
B	1	3			4	1	1	11
F				1			2	19
H				1			2	21
K				1	1		1	17
N			1					12
V			1	1		2		19
	1	3	2	4	5	3	6	99

Total Judgments, 123.
Correct Judgments, 99, or 80%.

other positions. The first two fall within the lower half of the screen, closer to the primary position of the eyes, and show by a greater percentage of correct judgments, when the fixation point is displayed, that this added element (the fixation point) has a real attention value.

This latter fact is established for the other positions on the screen as well, but we find no constant ratio between the percentage of correct judgments when the fixation point is present and when absent. In one position (No. 8) the difference in per cent is only 3 per cent, in another case (No. 4) it is 18 per cent. In the experiments with fixation, only two of the first five positions fall within the immediate vicinity of the fixation point, and of the first five in rank, four fall on the left side of the screen.

The average correct judgments for the three systems in Part I give the four highest position values for the lower half of the screen. The preferred positions for the top screen in this part of the experiment are in the upper half. The results prove that the relation of the screen to the primary position of regard is of importance.

The attention value of positions on the middle screen follows (see also Tables XI and XII):

With fixation point Position Number		Without fixation point Position Number
3	Highest Value	2
2		1
7		3
8		7
4		4
1		6
6		8
5	Lowest Value	5

Unlike the upper screen, this level shows a greater diversity in the rank of positions with and without the fixation point. When the fixation point is present, the first three positions fall within its immediate vicinity; without fixation, two fall in the same region. Consistent with the results with the upper screen,

TABLE XI

Judgments for Different Positions on the Billboard
Middle Level
Fixation Point in Center of Screen

1

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H	15					1	1	
N	9				1		2	2
F	20	1			1			
B	11	2	1	1	4	1		1
K	17	1						
V	18	2				1		
	90	6	1	1	6	3	3	3

Total Judgments, 113.
Correct Judgments, 90, or 80%.

2

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H		17						
N	2	9	1	1			1	
F		23				1		
B	3	14				3	2	
K		14						
V		21						
	5	98	1	1		4	3	

Total Judgments, 112.
Correct Judgments, 98, or 88%.

3

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H			15				1	
N			14					
F			22					
B		2	12		2	1	3	
K			17					
V			17		1	1		
		2	97		3	2	4	

Total Judgments, 108.
Correct Judgments, 97, or 90%.

4

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H				18				
N				11			2	2
F				22				
B	1	2	2	13	1	5		
K	1			20				
V				20				
	2	2	2	104	1	5	2	2

Total Judgments, 120.
Correct Judgments, 104, or 86%.

5

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H					15	2	1	1
N					9		2	3
F		3	1		13	6	1	
B	1			1	12	4	2	
K	1	1			18	4		
V		2		1	13	1		1
	2	6	1	2	80	17	6	5

Total Judgments, 119.
Correct Judgments, 80, or 67%.

6

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H						16	1	1
N	1		2		2	1	3	3
F			1		1	20	1	
B		3	1		4	11	5	1
K	1	1				15		
V					2	16		1
	2	4	4		9	79	10	6

Total Judgments, 114.
Correct Judgments, 79, or 70%.

7

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H						1	15	
N	1	1	1		1	2	10	
F		1					23	
B	1		2		1		13	1
K							15	
V							19	
	2	2	3		2	3	95	1

Total Judgments, 108.
Correct Judgments, 95, or 88%.

8

	JUDGMENTS							
	1	2	3	4	5	6	7	8
H							1	14
N				1			1	16
F								21
B	1	1	2		2		3	9
K								16
V						1		16
	1	1	2	1	2	1	5	92

Total Judgments, 105.
Correct Judgments, 92, or 88%.

TABLE XII

Judgments for Different Positions on the Billboard
Middle Level
No Fixation Point

1

JUDGMENTS

	1	2	3	4	5	6	7	8
B	18			1	2			
F	21	1			1			
H	11				1			
K	18			1	2			
N	8	1	1	1				
V	15				2	2		2
	91	2	1	3	8	2		2

Total Judgments, 109.
Correct Judgments, 91, or 84%.

2

JUDGMENTS

	1	2	3	4	5	6	7	8
B	1	20				1	1	
F		21			1	1	1	
H		11						
K	1	20				1	1	
N		11						1
V	2	13	1		1	1	2	1
	4	96	1		2	4	5	2

Total Judgments, 114.
Correct Judgments, 96, or 84%.

3

JUDGMENTS

	1	2	3	4	5	6	7	8
B	1	3	14		1			
F			24		1			
H			11					
K	1	3	14		1			
N	1		10			1		
V	2	2	13		1	3		
	5	8	86		4	4		

Total Judgments, 107.
Correct Judgments, 86, or 80%.

4

JUDGMENTS

	1	2	3	4	5	6	7	8
B		1	3	15	1			1
F		1	2	18	1		1	
H				10	1			
K		1	3	15	1			1
N		1	1	5			2	
V			2	14			1	3
		4	11	77	4		4	5

Total Judgments, 105.
Correct Judgments, 77, or 73%.

JUDGMENTS

	1	2	3	4	5	6	7	8
B	3				14		3	2
F					13	3	3	3
H					10	1		
K	3				14		3	2
N	1	1	2		6			1
V	5	2	1		7	1	2	
	12	3	3		64	5	11	8

Total Judgments, 106.
Correct Judgments, 64, or 60%.

6

JUDGMENTS

	1	2	3	4	5	6	7	8
B		1		1	2	13		1
F			1		2	20	1	
H						12	1	
K		1		1	2	13		1
N	2				2	7	1	
V	3				4	15		2
	5	2	1	2	12	80	3	4

Total Judgments, 109.
Correct Judgments, 80, or 73%.

7

JUDGMENTS

	1	2	3	4	5	6	7	8
B			1			2	17	2
F				1		3	19	
H							12	
K			1			2	17	2
N				2			9	1
V	1		1	2	2		16	2
	1		3	5	2	7	90	7

Total Judgments, 115.
Correct Judgments, 90, or 78%.

8

JUDGMENTS

	1	2	3	4	5	6	7	8
B				2	2		1	18
F							1	25
H								11
K				2	2		1	18
N						1	4	8
V			1	1	4	1	2	9
			1	5	8	2	9	89

Total Judgments, 114.
Correct Judgments, 89, or 70%.

a greater percentage of correct judgments for all positions occurs when the fixation point is present.

A comparison between these and the results obtained from the upper screen indicates that there is 9 per cent greater accuracy in the correct average judgment of all the positions when the fixation point is present than when absent, and a greater accuracy of 8 per cent in the case of the middle screen under like conditions.

Screen levels	Fixation Point	Average No. Correct	Advantage of observation with fixation over those without fixation point
Upper	With	72%	
	Without	63%	9%
Middle	With	83%	
	Without	75%	8%

The difference in judgment value for the upper half and lower half of each screen level with and without the fixation point gives evidence of a greater influence of the fixation point in the low marginal positions.

The left half and the lower half of the board, respectively, show greater attention value than the right half and the upper area of the board.

A greater attention results from the presence of a fixation point, and the interest centered within its vicinity acts against the tendency of the attention downward.

The same general tendencies hold for the upper-deck billboards. From the ordinary point of view the lower-deck boards have the advantage of a greater attention value.

As regards accuracy, the middle screen has a greater advantage over the upper screen than it has over that on the lower level.

TABLE XIII

Recapitulation, Upper and Middle Levels

		JUDGMENTS				JUDGMENTS		
	Screen	Fix. pt.	Correct	1st sub.	Screen	Fix. pt.	Correct	1st sub.
1	Upper	With	72%	5	Upper	With	44%	6
		Without	62%	5		Without	41%	7
	Middle	With	80%	5	Middle	With	67%	6
		Without	84%	5		Without	60%	1

		JUDGMENTS				JUDGMENTS		
	Screen	Fix. pt.	Correct	1st sub.	Screen	Fix. pt.	Correct	1st sub.
2	Upper	With	80%	6	Upper	With	58%	5
		Without	67%	1		Without	53%	5
	Middle	With	88%	1	Middle	With	70%	5
		Without	84%	5		Without	73%	5

		JUDGMENTS				JUDGMENTS		
	Screen	Fix. pt.	Correct	1st sub.	Screen	Fix. pt.	Correct	1st sub.
3	Upper	With	89%	1	Upper	With	70%	6
		Without	80%	2		Without	59%	6
	Middle	With	90%	7	Middle	With	88%	6
		Without	80%	2		Without	78%	6

		JUDGMENTS				JUDGMENTS		
	Screen	Fix. pt.	Correct	1st sub.	Screen	Fix. pt.	Correct	1st sub.
4	Upper	With	80%	2	Upper	With	83%	7
		Without	62%	3		Without	80%	7
	Middle	With	86%	3	Middle	With	88%	7
		Without	73%	1		Without	70%	7

Direction of Errors

The following table (No. XIV) gives the comparative

TABLE XIV

Table of Error-Tendencies

Method	*Erroneous Judgments* Toward the Left	Toward the Right	Downward	Upward
Chance order	43%	57%	47%	53%
Section 1—1-5-5-1 syst.	47%	53%	52%	48%
1-2-2-1 syst.	47%	53%	40%	60%
Section 2—Upper screen	50%	50%	61%	39%
Middle screen	35%	65%	58%	42%
Lower screen	35%	65%	40%	60%
Section 3—Upper screen (Fixation)	38%	62%	53%	47%
Upper screen (No Fixation)	40%	60%	52%	48%
Middle screen (Fixation)	34%	66%	60%	40%
Middle screen (No Fixation)	40%	60%	56%	44%

strength of the various tendencies shown in the erroneous judgments to move toward the left and toward the right, and upward, and downward from the position occupied by the stimulus, and consequently from the "position" of the correct judgments.

An illustration of the method of computation will make this clearer.

Considering the left and right half of the screen in the "chance-order" method, when the blank appears in position No. 1 (with one hundred and twenty-two correct judgments)[3] we find forty-four erroneous references of this stimulus to position No. 2, eight to position No. 3, and nine to position No. 4, totaling sixty-one false references downward. Again, there appear fifty-four erroneous references to position No. 5, thirty-eight to position No. 6, forty-four to position No. 7, nineteen to position No. 8, totaling one hundred fifty-five false refer-

[3] See Table I, p. 160.

ences to the right. Continuing this method for all positions (one to eight), we find the grand total of five hundred ninety-five erroneous references to the left half of the screen, when the stimulus was actually on the right; and seven hundred eighty-seven to the right half of the screen, when the stimulus was actually on the left, or forty-three per cent falsely directed to the left half, and fifty-seven per cent to the right half.

Applying a similar method to the consideration of the erroneous references to positions above or below that of the actual stimulus on the screen, with the "chance-order" method as before, we find regarding position No. 1 (eliminating positions 1 and 5) that there are one hundred sixty-two erroneous judgments with a downward tendency; in position No. 2 there is an upward tendency (including positions 1 and 5) of seventy-four erroneous judgments, and a downward tendency (positions 3, 4, 7, 8) of seventy-three erroneous judgments. Continuing for all positions (1 to 8) there is a grand total of six hundred eleven erroneous judgments with an upward tendency and five hundred thirty-one with a downward tendency, or forty-seven per cent in favor of the downward and fifty-three per cent for the upward; and so for all the other methods.

As between the leftward and rightward direction of false references, the greater percentage of such references is toward the right side, through all the methods.

In regard to the upward and downward directions, the tendency for "substitution" is upward with the chance-order and the 1–2–2–1 system, and downward for the 1–5–5–1 order.

In the second section of the experiment, there is a downward direction in substitution for the upper and middle screen. With the lower screen the tendency is upward.

In the third section of the experiment, there is also a strong downward tendency for those same positions which, in Section 2, called forth a downward tendency. On the whole, then, the direction of false reference is downward and toward the right, with the rightward trend stronger than the downward.

The writer cannot account for these tendencies on any physical basis. The screen was adjusted with reference to the primary position of the eye, and the speed of the exposure eliminated any muscular movement of the eyes during exposure.

PART II

THE VALUE FOR ATTENTION AND FOR MEMORY OF CERTAIN VARIATIONS OF FORM, SIZE, AND DURATION OF A SEEN OBJECT

Section 1: The Effect of Geometric Figures on the Process of Recall

The experiments here reported were concerned with the attention value and memory value of certain factors of form, size, and time, with reference to bill-boards.

The first problem was to determine, experimentally, the impressiveness and suggestibility of various geometric figures in combination with simple advertising phrases, as shown by their effect upon the recall of these phrases.

The first part of the experiment involved a series of ten tests once a week, before a class averaging eighty-two women and fifty-three men.

There were used five geometric figures—the square, circle, triangle, diamond and octagon—all of equal area; and a miscellany of twenty-five short, simple advertising phrases, each containing the word "Brown's". These were classified as food products, household, furnishing and wearing apparel; for example—"Brown's Shoes", "Brown's Desks", "Brown's Coffee", etc. These figures and phrases were arranged upon glass slides in such a manner that each phrase was centered within the figure employed. The slides were projected upon a screen, giving the image an area of 136 sq. cm. for each figure, and a height of 14 cm. for the letters and a length averaging 72 cm.

for each word—a size which was amply legible throughout the somewhat darkened room.

The weekly trial consisted of a series of ten displays each of two seconds' duration, with about six seconds' interval be-

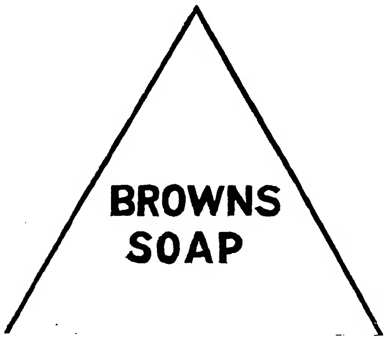

Fig. 3

BROWNS
STOVES

Fig. 4

tween the displays. The period of presentation was controlled by a metronome enclosed within a felt box. The intervals between displays, about six seconds, were not controlled with precision, but were determined by the time required for the removal and replacing of the slides. A certain rhythm, however, was practiced so as to keep the interval fairly constant.

The start of the experiment was announced by the word "ready", and at the close the class was instructed to write down all the phrases remembered, regardless of the order of presentation. One minute was allowed for this recall, a length of time which, it was found, imposed little or no restraint upon the subjects.

The entire experiment consisted of ten series. Each series contained ten different phrases, and during the course of the entire experiment each phrase appeared in four different positions in the series. Each figure appeared twice in every series, and twice in the same position in the series during the ten trials.

Each series was, for purpose of computation, divided into halves, the first half consisting of the first five members of the series, and the second consisting of the second five. During the

course of the ten tests, each phrase appeared twice in each half, and each figure appeared twice in each of the ten serial positions. Thus "Brown's Cocoa" appeared in positions No. 1 and No. 4 in the first half, and as No. 7 and No. 10 in the second

TABLE XV

Number of Recalls with Difference of Position, Order, and of Figure, for Either Sex, and for Both Combined

Position No. In Series	*Figure* △		*Figure* ⯃		*Figure* □		*Figure* ○		*Figure* ◇		*Total*		
	W	M	W	M	W	M	W	M	W	M	W	M	
1	166	100	158	101	160	101	150	111	153	101	787	514	1301
2	156	97	163	96	152	88	154	103	152	107	777	491	1268
3	145	97	157	108	154	99	164	99	159	94	779	497	1276
4	137	95	145	98	155	101	137	92	151	91	725	477	1202
5	145	92	159	94	135	85	127	76	134	93	700	440	1140
6	155	90	135	85	163	96	157	102	135	79	745	452	1197
7	150	92	114	73	122	88	125	69	132	85	643	407	1050
8	140	73	132	85	154	90	126	77	124	74	676	399	1075
9	133	82	127	75	108	75	139	88	143	88	650	408	1058
10	130	66	128	82	113	73	132	76	122	81	625	378	1003
	1457	884	1418	897	1416	896	1411	893	1405	893			
Total	2341		2315		2312		2304		2298				

half; the square appeared twice in position No. 1, twice in No. 2, No. 3, No. 4, etc. According to this system, each figure and phrase had the same local advantage an equal number of times.

Table XV gives the distribution of the recalls as affected (1) by the figure enclosing the phrase, and (2) by the position of the phrase in the series. The values of the figures, as determined by the number of correct recalls, take the following rank: triangle, octagon, square, circle, and diamond. However, the difference in their relative value is very slight.

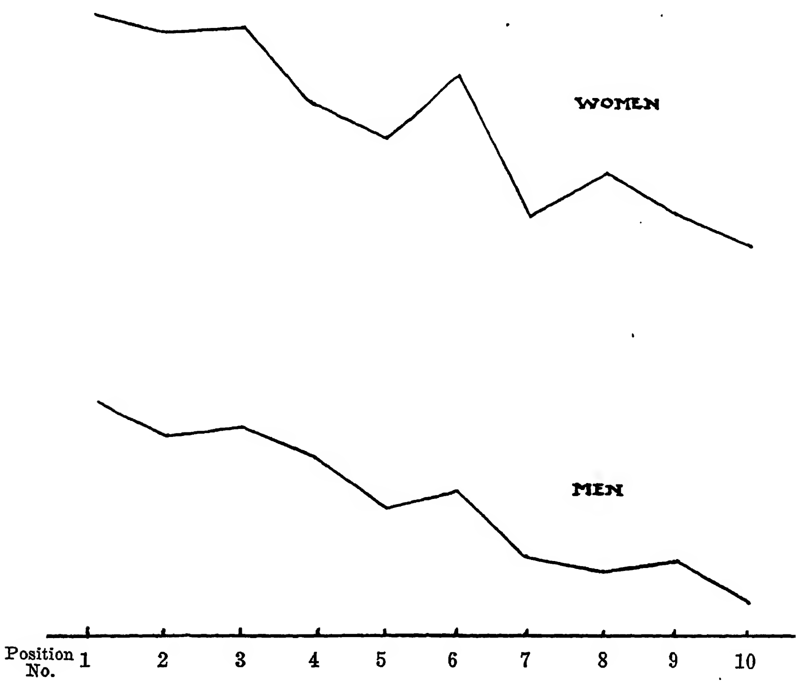

Fig. 5
Influence of Position in Series Upon Probability of Recall

The influence of position in the series may likewise be seen. Position 1 has the highest number of recalled words; position 10 the least number; with a somewhat irregular decline in memory value for the intermediate positions. It is surprising to find

that the last of the series, which might be expected to show some effect of its prominence, has so little attention value.

Dividing the series into halves (see Table XVI), the total

TABLE XVI

Influence of Place in the Series

	W	M	W	M	W	M	W	M	W	M	W	M
1st half..........	749	481	782	497	756	474	732	481	749	486	3768	2419
											6187	
2nd half..........	708	403	636	400	660	422	679	412	656	407	3339	2044
											5383	

recall of the first half (positions 1–5) shows an advantage of 6 per cent over that of the second half (positions 6–10). With the different geometric forms, this difference in the value of the halves varies from 4 per cent to 10 per cent in favor of the first.

From introspective evidence furnished by the subjects, it appears that there is a well-marked tendency to divide the series into halves and to recall the phrases of the second half first, "for fear of forgetting them", as they had more confidence in the first half. The first half gave an opportunity for

TABLE XVII

Influence of Practice

	Women Average number recalled	M.V.	*Men* Average number recalled	M.V.
Test No. 1	8.	.9	7.6	1.1
2	8.7	.9	8.2	1.
3	8.4	1.	8.1	1.2
4	8.5	1.2	8.5	.94
5	8.8	.98	8.5	1.
6	8.6	.9	8.2	.85
7	9.	.79	8.6	1.
8	9.	.75	8.4	1.1
9	9.4	.72	9.	.9
10	8.5	1.1	8.5	1.1
Average	8.69	.92	8.36	1.02

a review of the phrases during the intervals between exposures and they were possibly associated as a group. During the second half the recall was more of the disconnected phrases. There appeared to be a "break" at the middle of the series, whereupon many of the subjects attempted to employ greater attentive force. The increase in the value of position No. 6 in the series would perhaps be evidence of this.

The influence of practice during the ten trials is shown in Table XVII. For the entire series, the women have a higher average of recall, and a lower average deviation.

TABLE XVIII

Number of Persons Recalling All Ten Phrases

	Women	*Per Cent*	*Men*	*Per Cent*
Test No. 1	10	12	2	4
2	18	22	8	15
3	10	12	9	17
4	23	28	13	24
5	29	35	13	24
6	22	26	5	9
7	33	40	17	32
8	29	35	13	24
9	54	65	5	9
10	20	24	16	30
Average	24.8	2.99	10.1	18.8

Section 2: The Influence of the Duration of the Exposure

In this section of the experiment, consisting of four trials, each with a series of ten phrases as before, the time-factor was varied, i. e., the period of exposure on the screen was at times two seconds, and at times four seconds; the interval between exposures remaining constant at about six seconds as before. Each length of display was introduced in the series an equal number of times during the trials. In this part of the experiment the geometric figures were omitted; the influence of time as an attention factor was alone considered.

In Table XIX we observe that the relative value of the

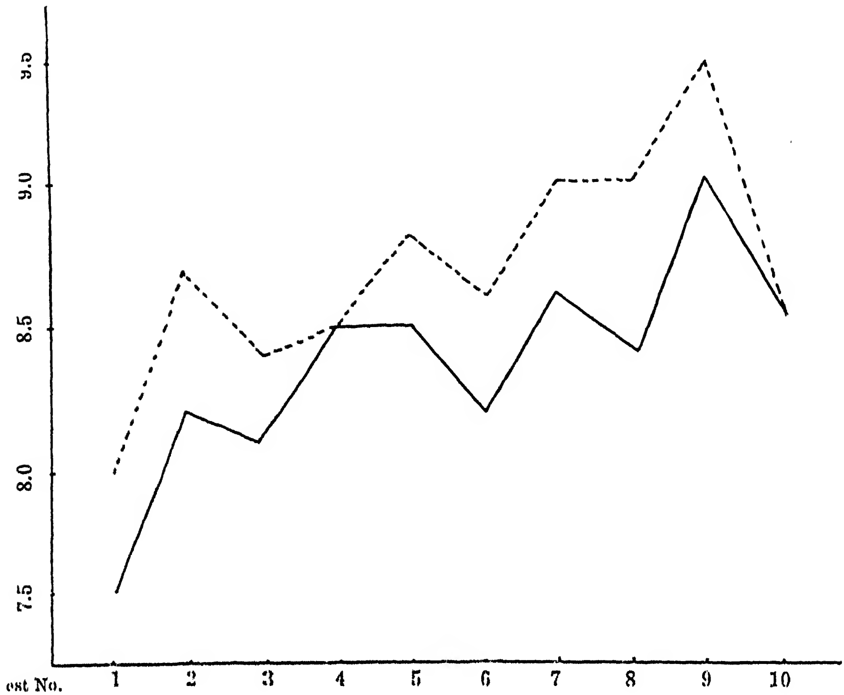

Fig. 6
Influence of Practice Trials upon Number of Words Recalled
Solid Line, Men; Dotted Line, Women

TABLE XIX

Time Feature

Position	Two Seconds	Four Seconds	Total
1	279	273	552
2	275	270	545
3	263	274	537
4	254	265	519
5	236	248	484
6	250	247	497
7	236	232	468
8	251	248	499
9	228	242	470
10	190	200	390
	2462	2499	4961

TABLE XX

Influence of Position in the Series

	Two Seconds	Four Seconds	Total
First half	1307	1330	2637
Second half	1155	1169	2324
	2462	2499	4961

TABLE XXI

Number of Persons Recalling All Ten Phrases

	Women			Men	
Trial	No.	Per cent.	Trial	No.	Per cent.
1	19	23	1	6	11
2	26	31	2	15	30
3	35	42	3	19	36
4	45	55	4	14	26
Average	31	37		13	24

TABLE XXII

Practice Influence

Two seconds

Women		Men	
Trial	Average	Trial	Average
1	4.5	1	4.1
2	4.1	2	4.0
3	4.5	3	4.3
4	4.6	4	4.4
Average	4.4		4.2
Percentage gain 2.2%.		Percentage gain 7.2%.	

Four seconds

Women		Men	
Trial	Average	Trial	Average
1	4.0	1	3.7
2	4.6	2	4.6
3	4.7	3	4.5
4	4.6	4	4.4
Average	4.5		4.3
Percentage gain 15.0%.		Percentage gain 19.0%.	

different positions in the series corresponds closely with the results given in the first part of this report. Position 1 has the greatest number of recall words, 10 the least, with an irregular decline in memory value for the intermediate positions in the series.

From the Table XX it is seen that the first half of the series (positions 1 to 5) has an advantage of 6 per cent over that of the second half of the series (positions 6 to 10). This is the same as that obtained in the first part of the experiment.

The number of words recalled for the four-second interval for each half is less than 2 per cent greater than for the two-second interval. The variations in time of display therefore affect the results but little.

From Table XXII we find that the result of practice corresponds closely with that of the first section of the experiment, except that the women have a more constant record throughout.

TABLE XXIII

Space Feature

Position	Small	Large	Total
1	392	396	788
2	391	381	772
3	393	393	786
4	384	379	763
5	355	353	708
6	381	376	757
7	360	380	740
8	365	352	717
9	361	365	726
10	326	337	660
	3708	3712	7417

TABLE XXIV

Influence of Place in Series

	Small	Large	Total
First half	1915	1902	3817
Second half	1793	1810	3600
	3708	3712	7417

Section 3: The Influence of the Size of Letters

In this section of the experiment, consisting of six trials, each with a series of ten phrases as above, the space-feature was

TABLE XXV

Number of Persons Recalling All Ten Phrases

Women			Men		
Trial	No.	Per cent	Trial	No.	Per cent
1	36	44	1	21	40
2	32	40	2	20	37
3	40	48	3	23	43
4	41	50	4	26	50
5	42	51	5	33	62
6	39	47	6	19	36
Average	38	46		24	45

TABLE XXVI

Practice Influence

Small

Women		Men	
Trial	Average	Trial	Average
1	4.5	1	4.4
2	4.6	2	4.6
3	4.7	3	4.6
4	4.6	4	4.6
5	4.7	5	4.8
6	4.6	6	4.3
Average	4.6	Average	4.55
Percentage gain 2.2%.		Percentage gain —2.3%	

Large

Women		Men	
Trial	Average	Trial	Average
1	4.6	1	4.6
2	4.6	2	4.3
3	4.6	3	4.6
4	4.7	4	4.5
5	4.6	5	4.4
6	4.7	6	4.8
Average	4.6	Average	4.5
Percentage gain 2.2%.		Percentage gain 4.3%.	

varied by using two different-sized letters. Duplicate phrases were formed with both sizes of type—one remained the same as before, and the other increased in the ratio of 4 to 2½. The same phrases were used as before. Duration of display was constant at two seconds, and the interval averaged about six seconds. Phrases in each size of letter occupied the same position in the series an equal number of times throughout the trials. In this part of the experiment, the geometric figures were omitted; only the size of letter was considered.

In Table XXIII we again observe that the relative value of the different positions in the series corresponds closely to that found in the first and second section of the experiment; 1 having the greatest number of recall words, and 10 the least number. From Table XXIV, we see that the first half of the series (positions 1 to 5) has an advantage of 2 per cent only over that of the second half of the series (positions 6 to 10). As regards the influence of the size of the type, there is but the slightest indication of any advantage in the larger type.

Summary and Conclusions of Part II

Serial Position.—From the results of the three different sections of this part of the report we may conclude that there is a different memory value for each position in the series. Position 1 has the greatest number of recalls, and position 10 the least; the intermediate positions show an irregular recall value. A "break" appears, dividing the series into two halves, giving position 6 an unexpected strength. This, however, is not as marked in Section 2, possibly because the change of the time feature gave a greater variety to the objective stimulus. Sections 1 and 3 having less interest, there was perhaps a greater degree of involuntary attention until the middle of the series was reached. Position 10, prominently located, has a surprisingly slight memory advantage.

Value of the Halves.—The recall value of the first half of the series compared with that of the second half shows a dif-

ference of 6 per cent when there were variations of the form and of the time, and 2 per cent when the space factor is introduced. The influence of practice may have entered here, rendering the position values less variable.

Figure Influence.—The small difference in the memory value of the different geometric figures may be due either to their insufficient variety or to the lack of prominence in the design displayed, giving the phrases themselves a greater attention value by contrast. We seem justified in the belief that the arbitrary combination of the two variables, that of form and text, introduced a conflict of ideas rather than an harmonious association conducive to memory power.

Duration of Exposure.—The four-seconds duration of display has an advantage of less than 2 per cent over the two-seconds duration. We may, therefore, conclude that there was an equal amount of voluntary attention distributed over each duration of exposure, and therefore, there was no marked difference in the persistence of the impressions.

Size Value.—There is less difference in results from the variations in space than that of time, indicating a small degree of attention-stimulus in the changes of size of letters used.

Practice Influence.—The number of persons recalling all the ten phrases in the first ten trials averaged 36.9; for the next four trials the average number of persons is 44; and for the succeeding six trials the average number was 62 persons. This increase must be attributed to practice, rather than to the manner of presentation.

There was a gradual increase for the number of correct recalls for the ten positions during the course of the experiment. In the first part of the report there was an average of 115.6 recalls for the various positions, 124.1 for the second part, and 123.4 for the third part. The average deviation in the first part was 9.1, and the second part 8.1, and the third part 5.4. The ratio of the positions became more constant, especially for the second half.

Sex Difference.—Of all the geometric figures the women's

results were most influenced by the triangle and least by the diamond; the men's results were least for the triangle, and most for the octagon.

While the women had a higher average of words recalled, and a lower average of deviation, the men showed far greater improvement from practice. But it must be remembered that there was in their case more opportunity for improvement.

Transmitted June 16, 1914.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
PSYCHOLOGY

Vol. 2, No. 3, pp. 199-265 May 8, 1916

THE PSYCHOLOGY AND PHYSIOLOGY OF MIRROR-WRITING

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UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

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THE PSYCHOLOGY AND PHYSIOLOGY OF MIRROR-WRITING

JUSTIN K. FULLER

The research to which the following pages are devoted was begun in 1911, and was continued with several interruptions to the end of the academic year 1913.

I avail myself of this opportunity to express my thanks to the officials of the Napa State Hospital; the California Home for the Care and Training of Feeble-Minded Children, at Eldridge; the California Institution for the Deaf and Blind, at Berkeley; and to other individuals by whose courtesy I was enabled to gather much of the data for this paper. I wish to thank Professor Brown for affording me all possible facilities in the psychological laboratory, and for his kind assistance. I am under deep obligation to Professor S. S. Maxwell, of the department of physiology, for reading the manuscript. The unfailing kindness, and the constant interest in my work evinced by Professor Stratton, I shall remember always.

Berkeley, California. J. K. F.

CONTENTS

INTRODUCTION

1. Definition

Mirror-writing is characterized by a reversal of the form and arrangement of the letters, which appear as if ordinary writing were held before a mirror. It in turn becomes legible and has the appearance of ordinary writing, when seen in a mirror.

2. Conditions Hitherto Recognized as Favorable to Mirror-Writing

It will be advisable to assemble in the form of a brief resumé the various conditions under which mirror-writing has been observed. It is found as a spontaneous occurrence only in left-handed children, or in adults after right-handed paralysis, though it can be acquired by anyone after practice.*[1] It may be deliberately performed as a trick[50] or as an amusement.[12] The ability is not at all rare, and may be possessed by all persons but remain unobserved.[3] The latent ability to write mirrorwise is ordinarily made evident in adults by some lesion suddenly rendering the right arm useless. But paradoxically, nearly every child at a certain period of its development will be found to produce spontaneous, fragmentary mirror-writing with the *right* hand.[31] Children whose writing is still forming may be observed to make spontaneous fragmentary left-hand reversals, especially in the up-and-down turnings of single letters, figures, etc. Similar reversals may be seen in the left-hand writing of many adults who write usually with the right hand.[5] Left-handed mirror-writing may be a physiological sequela of weakness by disease, of weak-mindedness in children, of left-handedness, or merely of absent-mindedness in a normal person.[55] Occasionally it is seen in feeble-minded or left-handed children, or in a patient who has had right hemiplegia in early life.[47] Numerous cases have been observed to follow right-sided hemiplegia. It has been ranked as first among the manifestations of aphasia[13] and on the other hand has been supposed to have no very special connection with aphasia.[9] It has been spoken of as a congenital tendency, almost a defect, in left-handed children.[12] A neurotic inheritance may aid in its acquirement; it is met with in some forms of mental weakness, and in some conditions of mental disorder allied to the hysterical; it is more common among women than among men, and is more easily acquired by the

*The superior figures refer to the List of References, pp. 262-265.

more highly nervous people; it may occur in cases of moral perversion and may be only temporary, recurring with the other symptoms of the disorder.[67] Some mirror-writers belong to the class of learned idiots, or *idiots savants*.[8] It is more common among high-grade imbeciles than among the left-handed.[64] As a pathological condition, left-handed mirror-writing is rather common in children with impaired intelligence, in deaf mutes, the blind, and in cases of katatonia.[31] Also it has been observed in cases of dementia praecox (under which heading katatonia has been included).[54] Severe, and as a rule chronic cerebral diseases, cerebral degeneration, or feeble-mindedness may cause its appearance.[59] It may be, but is probably very rarely, indicative of nervous disease,[54] and is not in itself a sign of mental defect although it is seen in such cases.[45] Various observers have claimed for it only pathological significance, but the majority agree that it is the normal writing for the left hand.

3. A Working Explanation of Mirror-Writing

Reversed writing is produced when the hand unaccustomed to writing produces the series of motions to which the other hand is accustomed (symmetrical accompanying movements). The nervous relations whereby this unusual mode of expression is attained has long been a question of interest wherever observers have noted its occurrence. The diversity of conditions which may lead to the production of mirror-writing has undoubtedly contributed in no small part to the confusion which attaches to the subject. An indication of the variety of these conditions has been given above, and a notion of the resulting confusion may be obtained from the hypotheses of the various authors, to follow on pp. 204 ff. Although the explanation of mirror-writing is a subject of controversy, it is generally admitted that the one hand, or more generally the entire side of the body, or any part thereof, acquires skill from the practice of the opposite part. Thus, if certain groups of muscles and nerves on the right side have been

trained to perform certain definite movements (resulting in a centrifugal writing), it will be the same definite groups on the left side which have gained in efficiency. The ability to write in a centrifugal direction with the left hand is due almost entirely to this "cross-education".

4. Three Kinds of Reversal

Written symbols may be reversed as a result of at least three fundamentally different types of control. I am primarily interested in but one of these types. This may be defined as the spontaneous, automatic, unpracticed kind which in certain rare instances has been noticed to accompany or follow such conditions as are mentioned on pp. 201 ff. (except right-handed reversals by right-handed individuals or *vice versa*). The mirror-writing which occurs in all of these conditions, I have classed together, because (*a*) the mechanism for the reversed writing is similar in all these cases; (*b*) there are certain psychological aspects common to these various conditions; and (*c*) all other forms of mirror-writing are distinctly of a different order.

(*a*) The motor complex for reversed writing is a constant factor. It will be considered at length in Part III, Section 1.

(*b*) The psychological aspects, when present, remove certain inhibitions to the functioning of the reversed-writing motor complex. The inhibitory process may be likened to a brake, which when released, will allow the mechanism to glide along unhindered. The psychological factor is thus highly favorable to mirror-writing. It will be treated in Part III, Section 2. The relations of the various experiments of Part II to the reversed mechanism and to the psychological factors will be taken up in Section 3 of Part III. In this part, I will endeavor to explain the interconnection which exists in all forms of mirror-writing.

(*c*) The other forms of mirror-writing may be divided into (1) the form which results from a conscious attentive endeavor to reverse the writing; this form will be considered briefly in Part III, Section 2. (2) A kind which occurs usually only in

single letters or in fragments of a letter, and is due primarily to a confusion of the left-right relation of objects in space. This will also be considered in Part III, Section 2.

5. Summary of Explanations of Mirror-Writing Offered by Various Observers

Clapham[18] believes that abduction is the more convenient movement for writing. He studied a child who could write with the left hand almost equally well in three styles—namely, mirrorwise (the style first learned), rightwards (as she was made to write in school), and with alternate lines in opposite directions (when she was absent-minded). He sees a parallel between this case and the history of writing, which was leftwards in the earliest Greek and Etruscan period, later "ploughwise", and finally rightwards.

Wilks[69] observes that if the arms be rolled about one another, the movements are exactly alike. If the arms are extended to the sides during the continuance of the same relative movements, the right hand will trace ordinary writing, and the left hand mirror-writing. The movements and the results correspond. Hence skill in copying with the left hand the usual form of writing is acquired only after long effort to overcome the awkward use of the arm, due to the different set of muscles that are brought into play.

Wray[71] says that left-handedness must not be taken as an indication of the anatomical superiority of the right hemisphere. Our ability to write mirrorwise more easily than rightward with the left hand, rests upon the tendency to automatism of movement in an opposite direction brought about by the movements of the hands in opposite directions while walking.

List[47] simply notes that mirror-writers use the left hand; hence the natural result is to write from right to left.

Durand[21] observed that among intelligent persons mirror-writing with either hand is difficult, because of the very strong habit of writing from left to right; but that in the unintelligent

there is an aptitude to write either style with the left hand. The image of normal writing being less strong in the latter case, the inclination is largely unhampered by it.

Grace Peckham[55] reasons, *a priori,* that mirror-writing may indicate a change in the perception of the nerve centres of the brain. But if this were so, the patient should read this form of writing more easily than the normal, a condition she has been unable to verify, with possibly one exception, in the literature. She therefore attributes mirror-writing in every case to a mechanical cause, the person finding it easier to write in a centrifugal direction: the "association of ideas and muscular action making this so." The reason lies in a physiological, not a pathological, condition; therefore anyone, when not exercising care and forethought, might be expected to write in a reversed direction with the left hand. Similarly the so-called "pathological" cases of mirror-writing are probably brought about through weakness by disease, weak-mindedness in children, or simply as a result of left-handedness.

Erlenmeyer[23] believed abduction to be the natural method for executing all finer movements. His corollary to this is that writing toward the right is a result of right-handedness, and the greater development of the left cerebral hemisphere is the result of right-handedness, not its cause. Consequently those who wrote from right to left must have been left-handed, for the right hand follows the general tendency of abduction.

Ireland,[38] while he admits that most actions requiring skill are more easily executed in a centrifugal direction, yet criticizes Erlenmeyer's illustrations. For instance, Ireland has seen quite as brilliant passages on the piano done in a centripetal as in a centrifugal manner. This is also true of many other delicate operations, such as using the sling, bowling and batting in cricket, fencing, swimming, sewing, and so on. Ireland[35 38] has shown by a number of experiments and observations that there is a physiological tendency for left-handed children to write mirrorwise. This tendency occasionally prevails in adults who for some reason use the left hand. As an instance, some Arabic

characters were unconsciously reversed by the left hand of a subject. Hemiplegia of the right side is also an important factor in bringing about left-handed reversals. His general conclusion is a modification of Erlenmeyer's theory, with the additional idea that two mental images are formed, one on each hemisphere of the brain. The image on the right is the exact mirror-reverse of the one on the left, so that the left-handed writer would trace) for (.

Kingman[42] cites several tests to illustrate the old idea that abduction movements are the more natural and graceful for either hand. He also supposes that "analogous pictures reversely formed" are developed in the right brain conjointly with those in the left in two ways: (1) to some extent co-ordinately; (2) by what may be termed an overflow process, occurring either concurrently or because the left centers have attained a maximum degree of development or training. Further, the conclusion is that the image on the left cortex may be "called into play with either left or right hand to produce ordinary writing", and the converse. However, writing from left to right with the left hand is as unnatural as mirror-writing with the right hand, which explains why mirror-writing is most frequently seen in those who are not up to the standard of the normal educated man. The latter is able to make the transposition of graphic memory at will, and consequently write either form with either hand. And "both of these graphic picture centres may also be correlated with the appropriate muscle motor centres to produce mirror or ordinary writing through the medium of the toes, lips, elbows, or any other part to which suitable apparatus can be attached."

Leichtenstern[45] assumes that the left hand receives its stimulus from the right cortex, and following its natural desire for abduction movement, produces mirror-writing. He speaks of a "peculiar opposition" found in the left hand to writing rightwards, thus making mirror-writing the easier form in all cases.

Acker[1] agrees that writing is more easily formed in a centrifugal direction. Also that mirror-writing has followed dis-

ease of the left side of the brain in numerous recorded cases. He states that there is a physiological tendency for left-handed children to fall into mirror-writing.

Buchanan[12] cites certain cases which "point with some clearness to the fact that the person who is using the right side of the brain . . . has a very strong tendency to write mirror-wise; and we may assume that in the case of the left-handed person the right side of the brain is so used." The author believes with Erlenmeyer that there is a greater natural tendency towards abduction than towards adduction.

Mills[50] holds that "special convolutions in the right hemisphere have in a quiescent and undeveloped state the same functions which are active in the corresponding convolutions of the left hemisphere." Impressions received by the left cortex of a normal person are recognized as normal or usual images, and as being right side up. The images formed on the right cortex are usually suppressed. When these parts of the left cortex are injured, their functions are re-acquired through the arousing and developing of the latent activities of the right hemisphere. For those cases of mirror-writing occurring in the absence of direct lesion of the left cortex (e. g., injury to right arm), he assumes that the development of the left cortex is arrested and the individual is guided by the images on the right cortex. Similarly, mere use of the left arm may cause the images of the right cortex to be aroused sufficiently to guide the arm. A possible explanation for some isolated cases of left-handed reversals may be that the individual can write with readiness in the centrifugal direction.

Bastian[9] thinks mirror-writing has no very special connection with aphasia. He believes that a centre for writing movements may be developed in either hemisphere for writing with the opposite hand. He criticises Elder's belief that there exists but one special centre, located in the left brain: for if this were so, how would one account for the fact that only five per cent of the subjects tested by Elder were mirror-writers?* Bastian

*See p. 210.

inclines to the view that "writing movements of the left hand are controlled by the conjoint activity of visual and kinesthetic centres in the right hemisphere, just as the writing movements of the right hand are controlled or co-ordinated by similar centres in the left cerebral hemisphere."

Bruce[11] deduces from his study of a case of dissociated personality, in which "the right and left brain alternately exert a preponderating influence over the motor functions", the separate control of the sides of the body each by the opposite cortex. Mirror-writing was the usual form when the patient was in the left-handed stage.

Auden[4] believes "that there are potential kinesthetic centres for writing on each side of the brain." For left-handed rightward writing the impulses from the motor centre which co-ordinate the movements of the left hand are "reinforced and overlaid by a train of motor memory impulses from the cells of the cheiro-kinesthetic centre for the right hand." For this reason mirror-writing is generally found in young children and is usually transitory, disappearing as the right hand becomes more facile in the use of the pen.

Peretti[57] supposes a dual brain action similar to that assumed by Ireland. He believes that mirror-writing in hemiplegia is due to the mental obtuseness of the patient, rendering him like a young child. He says that a woman hypnotized on the left side of the body, which he assumes implicates only the right hemisphere, traced mirror-writing with the right hand; and when hypnotized on the right side of the body, she wrote with the left hand towards the right.

Bianchi[10] notes that a characteristic of ordinary writing is that every people uses the right hand, no matter in what direction the characters are traced; and that the "psycho-mechanical" act of writing is executed by a reflex mechanism similar to that of oral speech, the sensation coming for the most part through the organs of sight, and to a lesser degree through the "auditive" sense. He thinks it impossible that the seat for the disposition of the words and the impression of the motions

necessary for their formation, and the impression of the image of the words, should be only in the left hemisphere. By their presence in the right hemisphere, even to a much slighter degree, he accounts for the cause of both the pathological (hemiplegic) and the more normal form of mirror-writing. He says:

In a hemiplegia of the right side it will therefore happen that the image, not calling forth, on the left hemisphere, any centrifugal motion in the muscles on the right hand, will oblige the extensor cellular groups in the sound right hemisphere to write from the left, because of the preserved remembrance of the muscular combinations associated with the image of the word.

Hence, there will be an identical centrifugal motion giving lithographic writing. If one writes centripetally with the left hand, the muscle groups are antagonists to the muscle groups used in right-hand ordinary writing, and thus give an "insupportable contraction."

Burr and Crow[11] think that associated movements are due to bilateral representation in the cerebral motor cortex of the parts affected, plus motor overflow. Thus, these movements result if an adult has not learned to restrict completely the random movements of the infant. Mirror-writing, depending upon these principles, offers a less complex problem than the wider question of associated movements in general. Simultaneous writing with the two hands is not naturally identical, but opposed. In this fashion, the ordinary educated man will write rightwards with the left hand only if he "uses his will to make himself do so", and the real reason imbeciles write mirrorwise with the left hand is not that they are imbeciles, but because being imbeciles they "permit the left hand to do what it will without trying to control it."

Rudolf[60] thinks that we get a double image in the visual centres, the one in the right side being the reverse of the one in the left. The impression in the right cortex of ordinary people is so poor, however, that it is not used for left-handed writing. Instead, ordinary writing is slowly traced out. But in a naturally left-handed person the impression on the right brain is

good, and therefore mirror-writing is the natural type for the left hand. Moreover, it would result that all persons showing right hemiplegia with mirror-writing are either left-handed or ambidextrous.

Campbell[16] is not convinced that writing is exclusively the function of one hand, although in writing "forwards" with the left hand the movements do not correspond to the usual right-handed movements; yet one may learn this form quite easily, and it does not seem that there are many disadvantages attached to such an accomplishment.

Elder[22] differs from the view that there are two writing centres. He tested 451 persons of different ages and sexes and found that 5.1 per cent, when first bidden to write with the left hand, reversed their script. He finds that the left-handed mirror-writing agrees in every detail with the usual right-handed writing, and therefore must be guided by the same centre. This centre could not be the visual centre, else the writing would be in the usual shape and not mirrorwise.

Allen's[3] conclusion is that the true graphic center is not coincident with either of the motor centers, but superior to them all. Thus he suggests that all the messages start from the same region of the brain. But at a lower level they are turned into different channels leading to analogous but sometimes heteronymous groups of muscles.

Russell[61] agrees with the theories of Allen and Elder, although, in the case he observed, the mirror-writing was very faulty and bore no resemblance to the normal right-handed writing of the patient. The single cortical centre should innervate homologous muscles, making the resulting left-handed mirror-writing perfectly normal. He intimates that the fibres connecting Broca's convolution with the lower centres are damaged, rather than the special centre itself. In addition, the frequency of occurrence of mirror-writing in aphasia "suggests that there may possibly be some special connection between the two conditions."

Jones,[40] although hazarding no explanation for the occur-

rence of mirror-writing, gives a rather good destructive criticism of some of the existing views. The only explanation which seems to him at all adequate, is that given by Mills in the *Encyclopedia Medica.* As most mirror-writing is left-handed, the movements are primarily guided by the left cerebral cortex through some preponderating influence which the cells on the left side have over those on the right. As a result the movements of the left hand are symmetrical with those of the right, and because the same relative muscle-groups on the two sides are used, mirror-writing will be the left-handed type. Some stress is placed upon the particularly close association of the two hemispheres through the corpus callosum. Even this explanation, says Jones, affords but little light on the subject. He is especially bitter towards the "retinal-image" and "mental-image" hypotheses. He remarks that the blind suddenly given vision do not interpret it as inverted.

Smith[63] notes that the various idiosyncrasies of right-handed writing will be copied in reverse by the left, but that these peculiarities will not be followed if the right hand writes in reverse. He is not able to decide whether this phenomenon is due to more or less facility of hand movement (as suggested by Erlenmeyer) or whether it lies deeper, in some unilateral brain perception.

A view having great divergence from previous hypotheses was offered by Hale and Kuh.[31] These authors formulate a theory, based upon the relation of objects in space to the complicated process of mental co-ordination. They call attention to the fact that right-handed fragmentary reversals are of far more frequent occurrence than left-handed mirror-writing; an observation which, if it had been made, was hitherto considered of little or no importance. Only by laboriously acquired experience do we learn to interpret the inverted image on the retina and produce an upright writing. The child and the feeble-minded, lacking this experience, or the adult suddenly deprived of it, reproduces the visual image in incorrect spatial relation; hence the mirrored or completely inverted writing.

Complete inversions are, however, rare; as the lateral relationship, being the last and hardest to acquire, is first to be lost. They claim that the link which unites all the various states in which mirror-writing shows itself is an imperfectly developed (in the very young or in some mental deficients) or pathologically disturbed (after hemiplegia and in certain acquired psychic disturbances) psychic association and co-ordination. But little credence is placed in the "abduction" theory of Erlenmeyer as an explanation for mirror-writing, because if this movement were a very powerful stimulus, mirror-writing in right hemiplegies would be the rule rather than the exception. The criticism of Ireland's theory is that modern physiological psychology cannot accept with such completeness the dual character of the brain; nor does this theory cover all cases.

Sweeney[61] attributes mirror-writing to a disarrangement of sensory impressions, with a resulting confusion or suppression of one or more of the factors which give us our idea of the spatial position of objects. Thus, a case of astigmatism may so interfere with the muscle sense as to prevent the proper association in the mind with other sensations and a normal transposition of the retinal image. Mirror-writing in such a case was completely eradicated by glasses that removed the reflex stimulation. The reason why mirror-writing is reversed, and not inverted, is that the lateral visual field is more extensive, and muscular movements are more frequent in a lateral direction and hence more easy and unconscious; the impressions conveyed to the mind are less in degree than are the vertical; the latter is a more purposive stimulus, and impressions conveyed by the muscular sense are less likely to be overpowered by the reflexes excited by eye-defects. The disarrangement in hemiplegia "may be that the unaccustomed use of the other hand for writing, and the confusion between former muscular habit, memory and the effort to adapt new centres to an unusual task would produce a reversal of writing when attention is not directed to the formation of words." The author criticizes Ireland's assumption of a corresponding but reversed image in the right brain of right-

handed individuals, as a "rather violent hypothesis", and asks why, if this be so, there is not inverted vision as well as hemianopsia when the visual centre of the left hemisphere is destroyed —a condition which does not exist. Also, he claims it harzardous to explain mirror-writing on the basis of mechanical ease, as Peckham does; for, if so, at least a tendency to mirror-writing should be shown by all left-handed individuals beginning to write, and not by a small percentage only.

Pendred[26] inclines to the view that "the pictures of letters in the boy's [referring to the case of spontaneous mirror-writing he is studying] memory centre are incorrectly stored and incorrectly reproduced." He thinks that the receptive apparatus in the occipital lobes may "play this strange prank with the naturally inverted pictures of letters received on the boy's retina." He notes "that the letters are not inverted, as would be the case if the brain merely failed to right the retinal images."

With regard to the sort of control utilized by subjects voluntarily writing reversedly, Abt[2] distinguishes three classes: (1) Those who before writing represented the form of letters as reversed to which but three of his thirty subjects conformed. This method was found to be slow and laborious, the writer was apt to become confused and there was frequent reversion to rightward writing. (2) Those who depended upon visual representation of the symmetrical movement. This was the usual method of control. Mistakes were rarely errors of reversion to rightward writing and never of partial reversion of a letter. (3) Those for whom, apparently, the auditory motor image immediately evoked the movement. The existence of this control Abt questions, for if the auditory motor image calls forth left-hand mirror-writing, how can it call forth by the same mechanism right-hand mirror-writing?

Downey[20] questions the possibility of classing six of her eight subjects (two used Abt's first method, modified) under Abt's second heading; she says: "For why may there not be a motor as well as a visual representation of a movement?"

Visual representation of a movement was rarely spoken of, but grapho-motor control was frequently insisted upon, sometimes as a matter of anticipatory imagery. Downey accepts the possibility of a purely motor representation of the movement.

6. Classification of Previous Theories

The theories of mirror-writing may be divided into six groups, viz.:

(A) The explanations which depend upon the facility of external motions of the limbs.

> Advanced by Durand, 1881–2; Peckham, 1886; Clapham, 1894–5; List, 1901; Wilks, 1902; Wray, 1903.

(B) Those which place emphasis upon the facility of centrifugal motions of the limbs, but in addition attribute the ultimate causation of specific movements to bilateral representation on the cerebral cortices.

> Advanced by Erlenmeyer, 1879; Ireland, 1881–1893; Leichtenstern, 1892; Acker, 1894; Mills, 1894; Kingman, 1905; Buchanan, 1908.

(C) Those hypotheses based primarily upon bilateral representation on the cerebral cortices. This group is closely allied to group B.

> Advanced by Peretti, 1882; Bianchi, 1883; Bruce, 1895; Bastian, 1898; Campbell, 1903; Rudolf, 1903; Auden, 1909; Burr and Crow, 1913.

(D) Those that admit but a single writing centre.

> Advanced by Smith, 1879; Allen, 1896; Elder, 1897; Russell, 1900; Jones, 1903.

(E) Those that depend upon disturbance of vision or of the visual centre.

> Advanced by Sweeney, 1900; Hale and Kuh, 1901; Pendred, 1908.

(F) Those which recognize various controlling factors for

individual voluntary reversals. Thus the movements may depend upon motor, visual, mental or auditory-motor imagery.

Advanced by Abt, 1901; Downey, 1908.

A closer examination of the relative value of these groups, as well as any criticism of them, may be best postponed until my own experiments and observations have been given.

PART II

EXPERIMENTAL FINDINGS

I have arranged the following account of my own experiments to conform in a general way to the degree in which the conditions favored the production of mirror-writing. A fuller description of the relation of these conditions to mirror-writing will be found toward the end of Part III.

1. Hypnosis (4 subjects)

These subjects were normal, but were tested when in the deeper stages of hypnotic sleep.

Subject A. Twenty-nine trials writing single simple words with the left hand. Of these words, twenty-four were entirely reversed. Thirty-four trials, single letters, twenty-eight were entirely reversed. Of the six that were not completely reversed, five were partially reversed.

Subject B. Thirty-one trials with words, seven trials with sentences, thirty-nine trials with letters. Each and every one was reversed. The subject showed no hesitation whatever; the reversals were easily and rapidly written. During this test, the subject was hypnotized four separate times, at periods of from one to two weeks apart, and each time produced mirror-writing post-hypnotically as well as while hypnotized. According to her statement, she has never been inclined to left-handedness. She was unable to decipher the writing, unless by the usual means of retracing each separate letter. After the four tests, I explained the matter of mirror-writing to her. Then,

using a planchette, I desired the subject to devote her entire attention to the problem of mirror-writing.* The result was a slow, hesitating, poorly executed form of reversal, typical of what will later be described as attentive mirror-writing.† I then carried the subject through successive stages of distraction of the attention from the left hand, and of dissociation of the mental from the motor functions, until she arrived at that stage of abstraction so nearly allied to hypnosis that the mirror-writing was automatic and complete. In each successive stage, the automatic character of the reversed writing showed a corresponding increase. As an example: the subject tapped with her right hand with the greatest possible rapidity on a telegraph key, at the same time that she said the alphabet backwards and wrote words with the left hand. Several words would be written in a rightward direction, then one or two or three would be reversed directly back over the words just written. No hesitation occurred between the two styles, and the reversed writing was quite as rapid and was better executed.

Subject C responded in only a slightly less degree than did subject B.

Subject D. None of forty words was reversed. By using various suggestions to the effect that the automatic and attentive apparatus should be dissociated, I succeeded in gaining a complete mirror style from the reagent's left hand; after this the subject was just as amenable to the different tests as was subject B.

2. Hysteria (1 subject)

Accompanying the other symptoms of the disease, there was complete anesthesia of the left side of the body—shoulder, arm, and pectoral region. I placed her left arm on the planchette

*The planchette, on a large piece of paper, I found most useful in many tests. A minimal amount of attention need be directed to holding the pencil, and to its position on the sheet; moreover, muscular weariness in prolonged tests is reduced. The result is that muscular responses to feeble stimuli are much more marked.

†See p. 241.

but obtained no response. Upon suggestion that it was the right arm which rested on the planchette, and that she could write just as well with the left arm, etc., I finally succeeded in getting writing from the left arm, though the patient was unaware of the movement of the arm. The writing was entirely mirror-fashion.

3. Drugs (25 subjects)

I thought that, by the use of drugs, I might simulate to some extent the conditions which are most favorable to mirror-writing with the left hand.

a. Alcohol (18 subjects)*

The first portion of the test was the same in every case. It consisted in holding the patient's right arm, and forcing him to write, or to make the motions of writing, with the left. The process was accomplished as quickly as possible, giving the patient very little time to collect his wits or to plan his motions. Ten trials were taken with an interval of two minutes between each. One subject, E, deeply influenced by the drug, wrote letters, words, and entire lines in mirror-writing.

Four patients were in a comatose condition and were examined immediately upon revival by aromatic spirits of ammonia. Two of them, F and G, indicated that they would write (i. e., made definite writing motions, which could not be recorded owing to the conditions of the tests) exclusively in a reversed direction; one (H) indicated a reversed direction in about fifty per cent of his movements; and another (I) showed no tendency to reversal, aside from the purely random nature of many of his motions.

The remaining thirteen reagents were less completely under the influence of alcohol. Eight of these (grouped as J) evinced considerable doubt and usually showed a tendency to stop and figure the thing out. Prodded on to the attempt, they often

*The alcohol was not administered for these experiments. Subjects were found in various localities and were tested on the spot.

showed impatience and dashed off their word now rightward and again leftward. The greater the anger and haste evinced, the more likely was the writing to be reversed. The other five (grouped as K), though well intoxicated, were less so than group J. They showed very little tendency to reverse their writing, and then only when they could be forced to write immediately after the signal was given.

The second part of the experiments with alcoholics was subject to much variation, as one plan or another suggested itself and was tried out. Thus, suggestion in one form or another was tried in each case. By this means the percentage of reversals was increased, especially in the relatively less intoxicated stages. Two of group J and one of group K became so adept, with a little instruction, that it seemed quite impossible for them to write rightward.

b. *Cannabis Indica* (3 subjects)

Subject L (myself). In 122 trials at writing words, seventy-two per cent were completely reversed. In 240 trials at writing individual letters, the letters were completely reversed, or hesitation was shown as to how to begin the letter, or the letter was reversed in part, in eighty-one per cent of the cases.

Subject M. Of eighty-one trials at writing words eighty-four per cent were completely reversed. Of 106 trials at writing individual letters, the letters were completely reversed in sixty-six per cent of the trials; hesitation was shown as to beginning the letter in six per cent of the trials; and the letter was reversed in part in three per cent of the trials.

Subject N. In ninety-six trials at writing words, two per cent of the words were completely reversed. Of 145 trials at writing individual letters, three per cent were completely reversed; hesitation and confusion were shown in twenty-nine per cent of the trials; and the letter was fragmentarily reversed in thirteen per cent of the trials.

A few trials at right-handed writing were given in each case

before the left-hand tests were started. In no case was there any indication of reversal.

As usual, after the regular tests were finished, variations were added in the attempt to locate some definite factor which would either favor or retard the production of mirror-writing. Here, as before, suggestion was found to be most potent. Conversely, merely to point out to the subject the queer appearance of his reversed script was enough to stop altogether, for the time being, its production.

c. *Ether* (4 subjects)

The trials are necessarily few in number because of the very short duration of the stage of intoxication which I found by testing other patients to be most favorable to mirror-writing. This is during the recovery of the patient, but before he is conscious. The giving of the drug was, of course, not in my hands, as the patients were being anaesthetized for minor operations. Usually the patient merely indicated, by a jerky sweep of the arm, the direction of his writing. With the right arm, this direction was always rightward; with the left arm:

Subject O. Eight trials, words all reversed.

In twelve trials in which I attempted to make the subject realize his error, ninety-two per cent of his movements were reversed; that is, this patient could not be made to realize that he was writing in any but the normal manner. Later stages in his recovery were not satisfactory, as he was quite conscious.

Subject P made no reversals.

Subject Q hesitated before each motion, and only in two of eleven trials did he reverse. Single letters were not reversed in nine trials. In seven of thirteen trials he was induced to reverse words or letters by suggestions to that effect.

Subject R reversed in four of nine trials with words; in six of eleven trials with letters, the other five trials showing doubt and no motions of a decisive nature. Suggestion in nine trials produced no noticeable increase in the reversals.

4. Abstraction (15 subjects)

The persons experimented upon were in normal life, ten belonging to no particular class, while five were engineering students. Different methods of inducing abstraction were employed; for instance, mental arithmetic, crystal-gazing, and so on. In half the trials the reagent kept in his left hand a pencil held on paper in position to write; and in an equal number of tests he rested his left hand on a planchette. Immediately upon a signal, he was to begin a word. I found that only the first line was of any value, for almost as soon as they began to write, they awoke from their abstraction, and summoned attention to their aid in finishing the word. The first stroke was started mirrorwise in some thirty per cent of the ninety trials I deemed it fair to accept as answering all the conditions of the test.

5. Insane (5 patients)

These patients were confined in an institution, and no hope was felt with regard to their recovery. Unfortunately, the diagnoses of the particular types of disorder they suffered from were not satisfactorily determined for inclusion in this article.

Subject S retained just enough intelligence to write a few words. He looked at me when writing, and not at the script. With the left hand, mirror-writing was formed without exception.

The other four patients wrote mirrorwise from fourteen to seventeen per cent in some eighty-five trials each, given at intervals of several days. Hesitation was shown in starting a letter in about twenty-three per cent of eighty trials each.

6. Hemiplegia (right side paralyzed, 2 insane patients)

Subject T could not be induced to write in anything but a reversed direction. His general mental condition was so poor that he could remember only a few letters.

The other patient was in better condition mentally. He

produced mirror-writing in but nine per cent of 116 trials. By suggestion, I could raise this percentage only to 11 per cent. Of 118 trials with individual letters, eight per cent were entirely mirrorwise, ten per cent showed some hesitation or fragmentary reversals. That is, there was comparatively little hesitation; the letter was either reversed or it was not.

7. Feeble-Minded (69 patients)

Of these, twenty-six were in the intermediate grade (second reader) of school. Asked to write their names with the left hand, only two produced mirror-writing. Directed to write a double word, such as "Glen Ellen", with the left hand, but to turn the paper through an angle of 180° in its own plane, between the two words, I found that six wrote "Ellen" in mirror-writing, including the two above, who wrote "Glen" mirrorwise as well. Eighteen of the twenty-six showed, in all the tests, marked confusion in starting; the line now being started mirrorwise, and then in its usual direction. When I wrote mirrorwise the word "California", but three of the patients had the slightest difficulty in copying the word reversed.

Of twenty-three patients in the advanced grade of the school, studying geography, etc., but one wrote mirrorwise with the left hand. Testing as above with the words "Glen Ellen", but three reversed "Ellen". Less confusion than in the first group was shown in starting a letter with the left hand.

Twenty other patients—nine children, eleven adults—were tested; these were of low grade, and not in the school, although they could write a few words or letters. One half were chosen on account of a marked neurotic history; the other half were as free from anything but pure "feeble-mindedness" as I could find. Of the first ten, six proved to be mirror-writers, two of the remaining four could be confused into mirror-writing, while the other two could not be induced to write mirrorwise at all. Of the last ten, but one wrote mirrorwise, only two could be confused, but all of them could copy, in reverse, words written in mirror style.

In examining the histories of the forty-nine school patients, I found that with three exceptions, every patient who had shown a tendency to mirror-writing had a neurotic taint other than feeble-mindedness. Thus, one had epilepsy; another, a hysterical mother; another, an insane father; and so on. Of the remaining patients, one-fifth gave a similar history, the rest being classified as merely "feeble-minded" or retarded. The neurotic tendency would lead to mental confusion, whereas the feeble-mindedness would place the patient in the same class as young normal children. This, as will be seen later, is an important point in the problem of mirror-writing.

8. Deaf and Dumb (77 patients)*

Of forty-two in the upper grades in the school examined, but two wrote mirrorwise with the left hand. Twelve of this number, exclusive of the two above, wrote the second word mirrorwise upon turning the paper through an angle of 180° in its own plane. Thirty-five showed great readiness in copying words after I had written them mirrorwise.

Of thirty-five deaf and dumb children in the lower grades, none showed the slightest desire to reverse letters or words. After a few trials, some of the children could be confused on such letters as *S* and *N*. When asked to copy words written mirror-fashion, the majority were able to do so, but a few began at the left and copied rightward.

9. Blind (5 subjects)

I was inclined to doubt Soltmann's figures for the deaf and dumb, but thought they might agree more nearly with the left-hand writing of the blind. Unfortunately for my purpose, blind children are no longer taught to write long-hand, and I could find in the institution I visited but five children who could

*These tests on the deaf and dumb were made to verify a statement of Soltmann, quoted by Gould [28] p. 106 that of seventy-seven deaf mutes, thirty-five per cent wrote mirror-style with the left hand.

write. None of these evinced the slightest inclination to spontaneous left-hand reversals; nor could they be readily made to understand the usual explanation of mirror-writing, or to reverse their script. It should be understood that none of these five children was congenitally blind; with the congenitally blind a different set of factors might be operative, making left-handed reversals easier.

10. Normal Children (26 subjects)

First type, eighteen children who had just learned their letters. In no case, by any of the ordinary means, could I get any of these children to reverse their words, or even the letters, except that in rare instances they reversed such confusing letters as *S* and *N*. Often there was hesitation, but nearly always the correctly formed letters were written.

Eight children, a grade ahead of the first type, frequently reversed certain confusing letters and figures with the left hand. By employing various means to confuse them, this percentage could be considerably increased, and in one instance I succeeded, without suggestion, in getting several words in mirror-style.

11. Persons with Special Training of the Arms

Thinking that a person's occupation or his training in writing would have some bearing on the readiness with which the motions of the left hand would be reversed, I tried a number of tests, among which the following had the most instructive results. In the first part of each of these tests, nothing was explained to the reagents, who were merely asked to write the same things on a black-board, simultaneously with both hands, and centering the attention on the right hand.

a. Clerks (12 subjects)

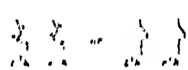
Analogous accompanying movements based on the visual or mental significance of the symbols was best illustrated by twelve clerks, highly trained in writing. With the left hand, the writ-

ing direction was always rightward; no indication of reversals in fifty-eight trials. When the same reagents were urged to rapidity, one subject fragmentarily reversed three letters in thirty-two trials.

I carefully instructed them in the trick of mirror-writing. If given plenty of time, they could reverse the characters with the left hand, but if urged to speed, in almost every instance they wrote rightward with the left hand. After some twenty trials, three of the reagents thought the mirror form the easier. But when I asked these three to write mirror fashion with only the left hand active, they were in each case lost. They hesitated, made two or three false starts, and finally produced a reversed script that was very much poorer and more labored than when both hands were active. Asked why this was so, each one told essentially the same story: that he thought first how the motions of forming the ordinary letter would look, while at the same time, or a little later in the case of simpler letters, the hand was engaged in moving in just the opposite direction. Sometimes, with certain letters, the first step seemed unnecessary, whereas, when both hands were active, little or no attention was given to the left hand. The other nine, after considerably more practice, arrived at the same conclusion.

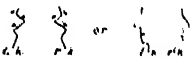
b. Plasterers (12 subjects)

Analogous accompanying movements based on motor habit was best illustrated by twelve plasterers whose trade requires that both hands make similar movements simultaneously. They drew on a black-board any figures that occurred to them, also copied several figures more or less meaningless, and followed the motion I made when drawing other figures. As usual the subject was at first unaware of the purpose of the request. In all cases the left gave a correct imitation of the right hand, i. e., the figures were:



Subjected to the same tests as the clerks, they were more

backward in learning, probably because they had less imagination. On the other hand, the clerks and students found it much easier to draw arbitrary figures similarly related, i. e.,



than did the plasterers, after this problem had been set them. In fact, several of the students drew figures in both relations before any definite direction had been given.

12. University Students (31 subjects)

Merely asked to write simultaneously with both hands, they gave no indication of mirror-writing. I now told them imperfectly what might be expected, merely giving them a hint; I then asked them to close their eyes, and to write *rapidly* with both hands. Six showed a rather strong tendency to reverse the left-hand figures. It is significant that all of them reversed a few lines, mostly the first strokes of the figures. About a dozen trials each were given. Furthermore, this ratio more than doubled when the reagent was placed in a condition of abstraction (mental problem, etc.) When I finally explained that it was easy to reverse the left-hand script, every subject found this so, after a couple of trials. They also found it much easier to reverse the left-hand script when the right hand was passive, than did the clerks. They found, with a little practice, that it was much easier to reverse with the left than with the right hand, each being used separately.

I noted in all the above reagents that if both hands are active, the left-hand figures are much more cramped, are less freely executed and less pleasing to the eye when drawn in a rightward direction than when reversed. Again, after the reagents were well practiced, as a rule they found it easy to write mirror-writing with the right hand, when attending to the left hand, which wrote rightward. Any peculiarity of the strokes, or their relation to one another such as is apt to occur when we use the left hand for writing, will be observed in reverse in the writing by the right hand.

13. Reversed Visual Field (16 students)

I employed a right-angled prism with broad faces, which by means of straps could be adjusted comfortably before one of the subject's eyes, the other being blindfolded by a curtain dropped from the front of the gear.

Sixty-four trials at writing with the right hand produced no evidence of reversals. Sixty-eight trials at writing with left hand—rightward direction in eighty-seven per cent; and scratches, i. e., starting lines in one direction or another, and as soon discontinuing them, confusion, and inability to produce anything like rightward or reversed writing, in thirteen per cent. Only in seven of the above sixteen reagents did this confusion occur.

The subject was then asked to pay particular attention to the visual appearance of the writing. With the right hand, this made very little difference; the reagent was apt to make one or two false starts, but in no case was a complete word reversed; and very soon he struck off in a rightward direction. With the left hand, however, the thirteen per cent of confusion was raised to ninety-one per cent. Only after the subject was familiar with the apparatus did he produce anything resembling letters; and then he usually guessed the purpose of the experiment, making further results of little or no value.

Using fourteen students who were unfamiliar with the apparatus, I attempted to find the percentage of meaningless figures that would be reversed. The tests I found most useful required the memorizing of a series of five figures by eye alone; the subject had then to put the prism before the eye and write off the figures with the right hand and then the left hand, without depending upon any particular control. Then I would caution the reagent to depend as fully as possible upon his visual remembrance of the figures; and again, upon the muscular remembrance. The next series involved the learning of a new set of figures, but principally by drawing them over and over with the right hand. Then after adjusting the mask, the

tests were repeated as in the series above. A third series was similar to the above, except that the left hand was the active member by which the learning was accomplished.

In the following table the method by which the figures were memorized is indicated as the "series". The "control" indicates the sense which the reagents were cautioned to depend upon. The first column of figures is the number of reagents, with, in the second column, the average number of their reversals in every twenty trials.

Some additional series were tried in which the learning of the figures was with the field reversed, and the test was with a normal field. Except that the reagents' surprise was a bit keener, the results were essentially similar to those of the series above.

PART III

THE EXPLANATION OF MIRROR-WRITING

1. The Physiological Factor in Mirror-Writing

The majority of authors agree that there is present in the right brain a centre which governs left-handed mirror-writing. Such an explanation very readily is suggested. The multiplicity of interpretations it permits allows infinite variation to accord with many diverse aspects of isolated cases. Yet I can not accept this theory as the most satisfactory explanation. I hold that a single "centre" is adequate to cause all of the manifestations of reversed writing. The very elasticity of the double-centre theory occasions complications, even contraditions, when one attempts to correlate all the cases and modified explanations and experimental findings. Again, it is against the concepts of modern physiology to think of a separate graphic centre—as such, or in any of the modified or reduced forms set forth by various investigators in this subject—as located in the right brain of right-handed indviduals. Also consideration of experimental data and study of the numerous cases reported in the

SERIES	CONTROL	RIGHT HAND		LEFT HAND	
		Reagents	Reversals	Reagents	Reversals
Series 1	General	11	0	10	0
		1	12	1	16
(Mem. by eye)		2	4	3	12
	Visual	8	0	3	0
		1	20	4	20
		2	17	3	14
		2	12	3	12
		1	7	1	2
	Muscular	13	0	3	0
		1	4	2	8
				9	4
Series 2	General	13	0	8	0
		1	6	3	12
(Mem. by right hand)				3	8
	Visual	12	0	3	0
		1	16	9	6
		1	7	2	4
	Muscular	13	0	4	0
		1	8	3	12
				6	8
				1	4
Series 3	General	12	0	11	0
		2	4	2	8
(Mem. by left hand)				1	4
	Visual	4	0	2	0
		7	10	1	20
		2	8	9	8
		1	4	2	4
	Muscular	11	0	11	0
		1	16	1	8
		2	10	2	4

literature, has led me to believe that such a supposition is not necessary.* Therefore it is the purpose of this section to explain the basic motor complex which enables the unpracticed left hand to produce a skillful, automatic reversed script.

In this section, I shall treat only of this physiological aspect, and not of the psycho-physiological whole, which will be reached only at the end of the next section.

As an observed fact, there can be no question of the ability of the normal man to execute either consciously or unconsciously associated movements, that is, symmetrical accompanying movements. As I have already noted, the exact central complex involved in such movements yet remains a matter of conjecture. However, I should feel that this paper were incomplete did I not express an opinion as to the nature of what is evidently a firm organic basis for these movements.

This opinion is, that in every instance of stimulation of a nerve on one side of the body (primary stimulus) there is, by the arrangement of the central paths, opportunity afforded for stimulation of the corresponding nerve on the opposite side of the body (secondary stimulus). It will thus occur that the graphic representation of the secondary stimulus will be an exact mirror replica of the graphic appearance of the primary stimulus. Accordingly all symmetrical movements may be traced ultimately to a single brain area. From this area, the motor complex of the side primarily intended to be active receives its stimulus. The opposite side is stimulated to a lesser degree either by its direct connection with the primary area; or indirectly by its connection with the opposite motor complex; probably both means are available. For the purpose of mirror-writing it is most convenient to assume the truth of the second alternative that the connection is between the motor cortices, through the corpus callosum. Evidence in favor of this contention may be summarized as follows:

*Unless, of course, one be developed by *practice* of the left arm, which is evidently not the case in spontaneous left-handed mirror-writing, which occurs suddenly, and without forethought or practice.

(1) In the first place, the tendency of modern physiology is to attribute to at least those parts of the brain herein considered, the function of an "exchange board" rather than those of a "directing monarch".

(2) Muscular, or kinesthetic, or deep sensibility is mediated by the rich supply of afferent (sensory) nerves distributed to voluntary muscles, tendons, ligaments and joints. The impulses carried by these fibres to the brain are necessary for the proper contraction of a muscle, and especially for any co-ordinated movements. Indeed, section of the posterior spinal roots containing the nerves from any region is followed by a loss of control of the muscles of this region hardly less complete than section of the motor roots. The muscles are withdrawn from voluntary control in spite of the maintenance of their normal motor connections.[32]

(3) Within the central nervous system, the fibres of muscular sense in part pass by the median fillet (sensory decussation) to the cortex of the opposite side. They end in the postcentral gyrus. This cortical sensory area is connected by association fibres with the motor areas of the pre-Rolandic convolution. By this arrangement, a reflex arc is formed. The co-ordination of this arc with other areas is necessary for the act of writing, as it is for the completion of any voluntary movement.

(4) When voluntary movement is undertaken, there must be some definite condition to fulfill or satisfy by that movement. It makes no difference if the condition is the highly co-ordinated act of writing, or if it is some relatively simple act, such as a gesture. The ultimate mechanism is identical. One becomes aware that a certain movement should be made, which is sufficient to start the act. Then by differences in the deep sensibility of the various parts affected, and co-ordination of exchanges of these various stimuli in the brain, we get the movement completed.

(5) Let us suppose, somewhat schematically, that an impulse is sent from the so-called writing center (center for memory of motions entailed in formation of written language) which

should result in the formation of a letter. Possibly the movement could be started, but even at its birth the co-ordination would be snuffed out, and *random* movements at best could follow, unless the motor area is stimulated by the afferent muscular sensations. Sufficient proof of this phenomenon is afforded by breaking the circle on the sensory side.

Writing is the sum of a number of simple signs. For instance, when forming the letter *L* we have grown accustomed to certain kinesthetic sensations resulting from a downward and outward stroke. These sensations, or stimuli, are necessary for an *external* expression of the central memory. And an *L* is never made by an *inward* stroke—which gives radically different muscular sensations from an outward stroke. When the point is reached where the horizontal line should commence, its direction is either outward, or the movement stops, whether the left or right arm is being used. By virtue of this assumption, reversed writing will be the logical result of a left-handed attempt at written speech. For only this style will afford kinesthetic sensations which agree with the usual writing of the right hand. The most likely inference to be drawn from this observation is the participation of a single writing-centre common to ordinary right-handed writing and to left-handed mirror writing. The motor impulse originates in this single writing-centre, and is transferred either through the motor emissary of the left cortex to the motor emissary of the right cortex, or directly to the motor emissary of the right cortex. The former seems more probable in cases where there is no lesion of the left cortex, by analogy to more general cases of associated movements. The latter must be admitted as a possibility to account for the transferrence of impulses in those cases where there is a lesion of the left cortex (right hemiplegia); for the writing-centre, being but a specialized part of the general motor apparatus, may be supposed to be as intimately connected (by the corpus callosum) with the opposite motor cortex as is the general motor cortex.

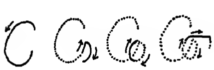
Or we may approach the question in another way. The fact

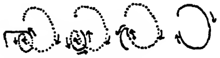
itself of the rich commissural connection of the two motor cortices would tend to detract from the hypothesis of the additional centre, by lessening the necessity for its formation. We will consider, first, that the greatest tendency for the hands to move sympathetically with rhythmic motions is in involuntary movements.*[39 27 66.] Second, the tendency is only slightly lessened when one hand follows involuntarily the conscious (but random) movements of the other. Third, most conscious movements are not accompanied by a visible muscular contraction of the opposite part. Although the crossed innervations do not function, they are nevertheless potentially emitted by the ultimate motor source of the movement with only functional dimunition of power, as is demonstrable. Instance the ease with which associated movements may be consciously made. Fourth, we have no experimental ground for supposing these simpler transmitted movements to be interrupted at any place before reaching the motor area of the opposite side. Quite the opposite is indicated by the difficulty we encounter in attempting to make synchronous movements which do not correspond. Fifth, the simpler impulses being crossed by such a direct method, it becomes needless to assume the far more cumbersome complex of an added station so complicated in nature as a writing-centre.

A readier appreciation of the real simplicity of mirror-writ-

*In this connection, I cannot refrain from mentioning a few primitive examples of symmetrical accompanying movements. When the corpus collosum is directly stimulated from above, symmetrical movement on the two sides of the body may be obtained. Another interesting illustration is given by a case of Kraft-Ebing's [42 p. 29]. The patient is hypnotized and a figure, as K, is placed on one side of the body and suggested as hot; a blister is raised at this area, and also a symmetrical and reversed blister on the opposite side. Yet another example is found in the "scratch reflex", "cross-extensor reflex", etc., of Sherrington.[62] If one leg of a dog, for instance, be stimulated, the homonomous leg makes scratching movements, while the opposite leg presents slight steady extension, *with some abduction.* Now, the extension is a protective measure to support the animal on three legs while the fourth is scratching. We, therefore, have *abduction* common in both legs. I have found that certain variations of this experiment, such as placing the animal on its back or side, may result in faint scratching movements of the opposite leg. The fact that here we deal with an overflow spinal reflex in no whit detracts from the value of the analogy, for writing itself depends upon a reflex arc, which we may suppose to be connected with one higher centre, as here indicated.

ing will be felt only by grasping the similarity between unconscious corresponding movements, semi-voluntary corresponding movements, and highly complex corresponding movements, as shown by the above brief summary of observations on sympathetic motions. That is to say, any movement of one side of the body is accompanied by a potential symmetrical impulse to the corresponding part of the opposite side. This is a physiological or anatomical provision. The functioning strength of the impulse varies with the psychological state or condition of the individual. Thus a writer has only to learn the knack of disengaging and occluding the stronger functioning paths and letting the impulse function along the weaker paths, to have the usually non-functioning impulse result in a skilled movement of the so-called unpracticed side. In other words, the table is turned, and the one system now occupies exactly the same position formerly held by the other. With this manipulation fully accomplished, the *visible* accompanying movements of the right hand become unnecessary for a fluent mirror-writing by the left hand. With a lesser degree of dissociation we have the characteristic mirror-writing that occurs in simultaneous writing with both hands, the attention being directed to the right hand while the left hand trails along semi-automatically. Or, simpler still, writing simultaneously on both sides of a sheet held in front of the body and in the sagittal plane.

There are additional objective phenomena confirmatory of the absence of the secondary centre. Those that are based on synchronous writing are so easily verified that I need scarcely more than mention them to have their bearing appreciated. It is easy for the average reagent to reverse his right-handed writing if his attention be given to his left hand while this left hand is forming normal writing. All the peculiarities and superfluous stroke, characteristically made by the left hand (e. g.  for the usual right-handed formation ) will be faithfully copied in reverse by the right hand (i. e.

) Again, it is practically impossible for any reagent that I have dealt with to write different letters *synchronously*. I have myself attempted this repeatedly but have acquired little skill in the performance.

I repeat that I am unable absolutely to refute the possibility of the additional centre in the writing complex. I have therefore collected a mass of evidence both for and against, and have formed from this my judgment. Thus, it might be that every movement of one side of the body is accompanied not only by a potential, but by a feeble symmetrical impulse to the corresponding part of the opposite side. By constant repetition, as in writing, the paths conveying these impulses would become more easily traversible—paths, in fact, that would be defined in exact proportion to the practice of the functioning side.* In this way a centre might become sufficiently formed to control left-hand mirror-writing in case of lesion of the left brain. Yet it would seem that even if such a supposition were tenable the centre need not be located in the right brain, since symptoms of apraxia on the left side in injuries to the corpus collosum have been reported, in which there was no lesion of the right cortex ([32] p. 229). Again, it is usually the uneducated right hemiplegic who resorts to mirror-writing. Did an additional centre control left-handed mirror-writing, one would expect exactly the opposite, for the centre must be developed in exact proportion to the practice of the right hand at ordinary writing.

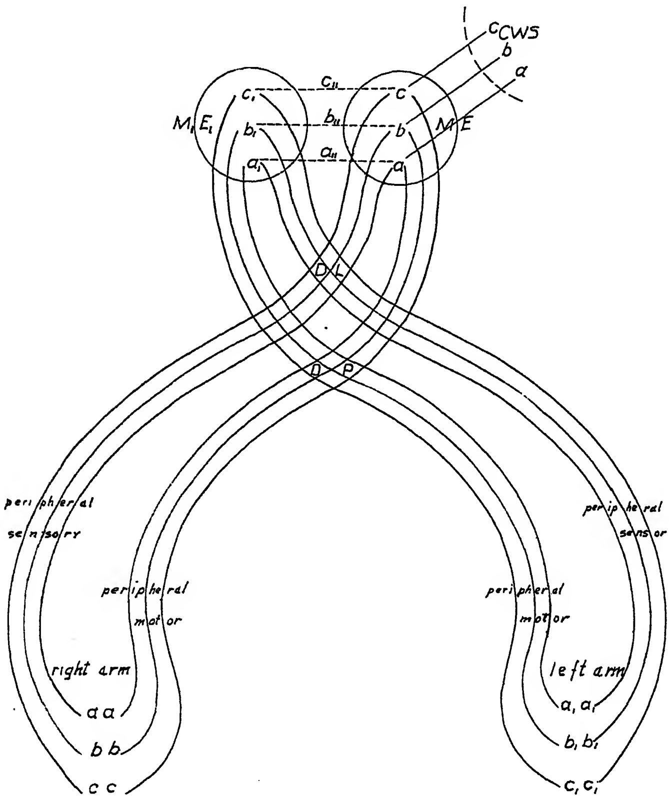
It seems to me that the best argument for the bi-lateral representation of the writing centre is that the faculty of mirror-writing has in rare cases been suddenly assumed by the left hand after paralysis of the right hand due to central lesion. The assumption in many instances has been that the central lesion has involved and destroyed the writing-centre of the left hemisphere. However, there is some doubt cast upon the location of the writing centre in Broca's convolution, as has been shown by some recent work by Marie. I know of no cases of

*See footnote on page 246.

mirror-writers, where to conclude from post-mortem findings, or from the study of aphasics or hemiplegics, that the writing centre, *as such* has been destroyed would not become extremely hazardous.

The writing-centre is a motor memory centre, developed by practice, and causing the formation of writing to be an automatic rather than an attentively controlled process. Yet it is never so automatic as even such complex acts as reading and speaking. It is superior to the motor area of the brain, in that the motor cortex is merely the emissary area, or the connection between higher centres and motor nerves. The writing-centre was originally identical with these higher, intellectual areas, but has become in a sense detached from them, and reduced to a unity by the forces operating to make it a physiologic sending station, requiring the least possible participation of the higher centres. Were the writing-centre alone destroyed, the patient might again learn to write as he did in the beginning. Clearly, the left-hand writing of such an individual would not be mirror-wise in any greater proportion of cases than the left-handed writing of the perfectly normal right-handed individual or of the right-handed child, who when asked to write with the left hand scarcely ever reverses. The only difference between this case and a right hemiplegia supposed to involve the writing centre, is paralysis of the arm. And in fact but a very small proportion of right hemiplegias are accompanied by mirror-writing. These cases in particular have been cited as evidence of destruction of the left-brained writing-centre. But then, may one not ask why the normal individual when using the left arm is not just as dependent upon the centre of the right brain as if the centre of the left brain was destroyed? In other words, use of the left arm should imply dependence upon the opposite centre, which means mirror-writing, whether or no the centre for the right hand is destroyed. Should the use of the right leg be preserved in a hemiplegic mirror-writer and the patient be unable to write rightwards fluently and automatically with this limb, it would be strong presumptive evidence that only one of

two writing-centres was destroyed, but I have never heard of such a case.



C. W. S. Centre for motor memory of written speech, which is identically related to kinesthetic sensations from either side of the body, those from the left arising from the movements of mirror writing.

M. E. Motor emissary of left cortex.

M_i. E_i. Motor emissary of right cortex.

D. L. Decussation of lemniscus.

D. P. Decussation pyramid.

a, *b*, *c*. Graphic demonstration of musculo-sensory innervations of right arm, which are correspondingly related to a_i, b_i, c_i, of the left arm, and to the commissural impulses a_{ii}, b_{ii}, c_{ii}.

All this leads to the conclusion that mere paralysis of the right arm has very little to do with mirror-writing. The presumption that mirror-writing depends upon the retention of the single writing-centre is therefore more logical than the assumption of an additional centre to account for reversed writing.

In the schema on p. 236 the idea embodied in the above discussion is summarized.

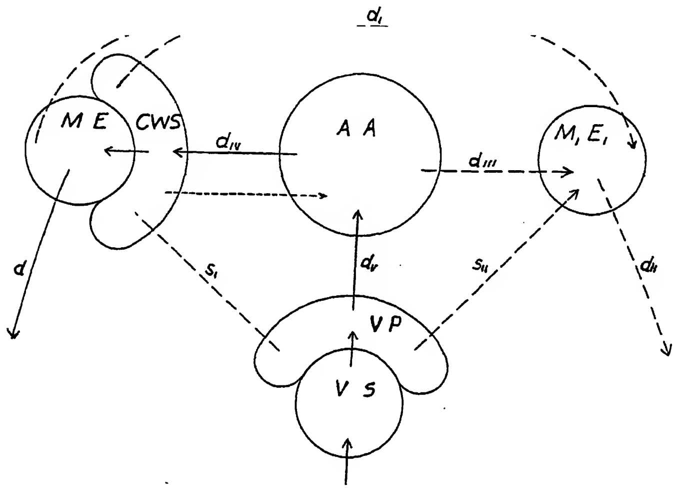
For the motor fulfillment of the act of writing we may suppose two essential steps: the first and lowest is the simple reflex arc, involving the motor areas; the second forms the connection between the writing-centre and the reflex arc. In associated movements in general, the primary impulse is received by but one motor cortex. From here a secondary impulse is transferred to the motor cortex of the opposite side. Mirror-writing, being but a specialized instance of associated movements, may be expected to follow this course. Destruction of the writing-centre will cause a loss of the faculty of habitual, or automatic writing, both by the right and left (mirroring) hand; but does not prevent the regaining of the ability to write by again repracticing the art with either hand.

2. The Psychological Factor in Mirror-Writing

The fundamental physiological relations which make of associated movements the simplest response to a bi-lateral stimulus, points to the validity of the conclusion of Buchwald;[13] Vogt;[68] Durand;[21] Nicolle and Halipré;[52] Ballet;[6] Meige;[49] Figuera;[25] Laprade[44] and many others cited herein, that the reversed style is the normal writing of the left hand. May one not ask, then, why mirror-writing is not the universal style followed by the left hand? Why is left-handed reversed writing not the rule rather than the exception? Were it not for some inhibiting influence, one would expect this to be true in the majority of cases. By a study of the cases adduced in the literature, I was led to the belief that this inhibition could be removed by

experimental methods. The nature of this psychological factor, and its relation to the experiments just reported, is set forth in this and the following section.

If you will recall the example of the letter *L* (given on p. 231), it was stated that the horizontal line will either be



s_i	Connection between visual area and motor emissary of left brain.
s_{ii}	Connection between visual area and motor emissary of right brain.
d	Emissary fibres from left brain to right arm.
d_i	Commisural connection between writing centre and motor emissary of right brain.
d_{ii}	Emissary fibres from right brain to left arm.
d_{iii}	Connection between the association area and the motor emissary of right brain.
d_{iv}	Connection between association area and writing centre.
d_v	Connection between visuo-psychic and association area.
V. S.	Visuo-sensory.
V. P.	Visuo-psychic.
A. A.	Association area.
M. E.	Motor emissary of left brain.
C. W. S.	Center for written speech.
M_i. E_i.	Motor emissary of right brain.

Modified from Lickley.

continued outward, or will not be drawn. The latter alternative will exist only if the former process is interfered with by our higher conception of what an *L* should be, i. e., how it should appear when on paper. With the visual significance of the anticipated movement as guide, the line will certainly be directed inward, supposing that the left arm is being used. By the inclusion of this element, embracing the 'visuo-psychic,' 'visuo-sensory', and 'association' areas, the provisional diagram on page 236 may be completed as in the figure on page 238, opposite.

To write from left to right with the left hand implies that the activities of the paths s_{ii}, d_{iv}, d_{v}, d_{iii}, (s_{i}, d_{i} are involved in the process, but to a much less degree) must be abnormally increased to the complete minimizing of the grapho-motor control as described above.*

Since the grapho-motor control is the simpler and physiological control, and is provided for by the arrangement of the central motor complex, I maintain that rightward writing by the arm on the same side of the body as the writing centre, is, usually† of the character of *drawing,* as contrasted with that of writing. For by "writing" I understand the smooth, easily flowing, spontaneous, nearly automatic series of movements which through training follow each other without the necessity of direct participation of the conscious or intellectual centres at whose instigation the process originally arose. Entirely the opposite of this facile, I might almost say unconscious, sequence is the labored, sometimes painfully conscious, visually supervised and poorly executed left-handed rightward "drawing".

*See Part III, Section 1, pp. 227 ff.

†"Usually" refers to the *occasional* use of the left arm (or the right arm in the left-handed individual), to distinguish this condition from the persistent left-handed rightward writing following permanent injury to the right arm, or the sensori-motor arc, and in which there are two possibilities for the writing to become automatic: first, the gradual formation of a new centre under the influence of constant practice controlled by the visual areas; or, second, the persistence of the more complex "drawing paths", including the participation of the old writing-centre, which by practice becomes semi-automatic. The end results are identical.

The impulse from the grapho-motor apparatus which, if unrestricted, would cause a left-handed mirror-writing, suffers by its reversal; by the addition to it of various impulses from the visual and association areas; and by the interference with the free passage of the impulses occasioned by the participation of the same higher centers which made possible the birth of the writing centre. Conversely, left-handed reverse "writing" would occur in direct proportion to the degree of suppression or inhibition of the interfering paths, from the visual and association areas, or—what amounts to the same thing—with the increasing canalization of path d_1.

We must remember that the visual complex predominates as an absolute "control" only in left-handed left-to-right writing. Using the right hand, we may attempt all sorts of confusions on the visual sensations, but they will never usurp control from the automatic habitual control of writing. This circumstance is well known by the following experiment: Place the right arm on the desk in a position for writing; then curve it inward, at the same time throwing the shoulder forward until the hand points toward the mid-sternal line of the body; a completely inverted writing will now be found far more natural than writing which to the eye appears normal. Only the *legibility* of our ordinary writing depends to a very great extent upon the visual stimulus. Thus, for proper spacing, for alignment, for the equality of letters, to avoid losing the way when in the midst of a word and so misspelling it; in general, for purposes of orientation, sight is quite necessary.[65] But this direct visual guidance may be dispensed with, although the central memory and the sensori-motor arc are indispensible. An observation of no little significance is that we regard the letters just written, and do not follow the movements of the fingers or of the pen point in tracing individual signs. Here is the most obvious distinction between the external visual control, and the "internal writing", as it has been termed. The former immediately follows, the latter immediately precedes the writing of the letter ([65] p. 61).

There is, as I have indicated, one type of mirror-writing which is purely automatic. For obvious reasons, it is this type of mirror-writing which most interests us. But there are two other controls which may influence one to a reversed writing. One is the voluntary visuo-muscular transposition of the motions made in forming the letters in reversed form. The other is the confusion of the lateral relationships of objects in space. These three control factors may be combined in any proportion; but each, if present as the major influence, will result in the production of a type of mirrored lettering that is distinctive.

The second type of control, then, occurs when one voluntarily endeavors to reverse his writing. If the condition extended no further than the conscious and attentive endeavor, it would have little to do with my problem, which is concerned primarily with the automatic reversals of the left hand. For until one gains some confidence in the use of the left hand; that is, until he has practiced writing somewhat with the left hand, this attentive form of reversal may be executed almost as well with the right hand itself. However, one should remember that here, as in every instance where a right-handed individual writes mirrorwise with the left hand (or *vice versa)* the mechanical or commissural fibres have been "trained" by the practice of the right hand. As one practices left-handed intentional mirror-writing, he feels the influence of this factor in a constantly increasing degree. He soon realizes that left-handed mirror-writing is far easier than right-handed mirror-writing. And before long he regards left-handed mirror-writing as easier than left-handed rightward writing; that is, the mirror style requires less attention, and is therefore more freely and rapidly written. However, without this preliminary practice one finds it practically impossible to dissociate what I have termed the psychological factor, or briefly, the attention, without the use of such artificial methods as are described (on p. 215 ff.) with the experimental relations. But when such devices are used, the mirror-writing is probably no longer attentively controlled, but is of the nature of an automatic reversal. For the same reason,

attentive or intentional left-handed reversals which have been practiced are to be regarded as having passed more to the automatic class of control.

This may be of interest, in that a possibility is suggested for the mode of origin of some cases of pseudo-spontaneous mirror-writing. It does not seem improbable that some people, through some whim would practice reversed writing. Finding this the most satisfactory style, both in ease and quickness, they might persist in its use till the conscious transposition of the images became unnecessary; that is, until the process has been relegated from the more essentially attentive to the more essentially automatic systems; until, in a word, we have an automatic reversal acquired through practice, which step is usually omitted.

The third type of control for reversed writing is contrasted in every way to the second type; it is due to confusion of the lateral relationships, and is for this reason always of a fragmentary character where unassociated with the other controls. Hale and Kuh[31] have called attention to the fact that this type of reversal is almost universal with the right hand of normal children of a certain age. Considering only the element of confusion, one would expect that the proportion of reversals by the left hand would be slightly higher with the same children, due to a greater disorder experienced in writing with the left hand the same confusing lines that are so often misdirected under the more favorable conditions of right-handed writing. We must not fail to consider, however, that as left-handed reversals are always aided by the physiologically crossed motor-complex, the left hand is more prone to this, as to other types of reversal. If this process of confusion be exaggerated sufficiently, the influence of the crossed automatic paths in contrast to the influence of the paths of attentive control will be so great that the fragmentary left-handed reversals will become complete, and a true automatic mirror-writing will result.

The left-right relations of objects in space are extremely elusive. They are acquired last and with most difficulty, are

hence easily confused in the process of learning and are the first to be lost in a process of spatial degeneration. Instances to the point are legion, and one has but to try an habitual movement before the mirror, or to watch a squad of recruits in facing movements to be convinced. On the other hand, above-below relations, being more fundamental, are rarely confused, which would explain the fact that spatial confusions of writing are so seldom those of fragmentary inversions. We may well expect, then, the normal right-handed writing of children at a certain stage of their development to be fragmentarily reversed, especially such confusing letters as *S* and *N*. Exactly the same incomplete mastery would explain the fragmentary reversals of uncultured adults. Add to these facts the condition that through some (usually central) lesion the left arm must be used by an individual who is strongly of motor tendency, and we need not be surprised if he is inclined to ignore the confusing, purely sensory relationships, and completely reverse his script; i. e., to rely upon the habitual, or motor, complex, rather than upon the intellectual complex of writing.

Conversely, we should expect the educated person, with his thoroughly mastered relations, not to be baffled by any condition comparable to that above. But what might ensue if this individual (or, as well, the uncultivated person) should combine aphasia with the enforced use of the left hand? All forms of aphasia, according to Marie, are due to interference with the posterior association area. But the only injury that can cause pure motor aphasia is injury to the lenticular nucleus. Motor aphasias are therefore due to a combination of cortical injury in the posterior association area (aphasia proper) and a subcortical injury (anarthria). As a corollary to this, aphasia is always associated with an impairment of the intellectual powers. Now, would it be assuming too much if the mirror-writing which follows hemiplegia were attributed to a similar circumstance? We should remember that mirror-writing but rarely follows cases of hemiplegia involving the left hemisphere. It may well be that the lesion in these exceptional instances is essentially

similar to a circumscribed aphasia. Or, at least, the lesion might cause disturbances comparable to a functional dissociation of the attentive from the automatic controls. Unfortunately, I have had an opportunity of studying only two cases of hemiplegics who could write at all. Both of these patients were confined in an institution for the insane. It would be unsafe to draw any conclusions from the fact that one would write, with the left hand, only in the reversed style, though the analogy is startling. My reasoning is therefore entirely *a priori*.

The "normal" or "abnormal" significance of mirror-writing forms a question of no slight importance. In attempting to decide it, I have been confronted with the ambiguity of the terms, which are apt to lead to some confusion. In ordinary writing, ideas are converted into the form of words which are transferred to the motor system and expressed as written speech. But writing with the hand not accustomed to writing is a novelty, and as such brings into play additional elements such as increased attention, which are ordinarily sufficient to influence the writing, in order that it may be legible to the writer. If these factors are prevented from increasing, or are reduced below the level they occupy during ordinary writing, the crossed motor complex may express itself in the form of mirror-writing by the hand accustomed to writing. However, one can not suppose that a novel event such as left-handed writing could occur normally uncombined with increased attention, unless the other extreme —dissociation—is reached. The fact that one appreciates this use of the left arm as something new or unusual focuses his attention at once upon the act. If not, something abnormal is indicated. And the attention, we found, is of first importance in reducing the probability of a reversed script. If, however because of the presence of the crossed motor complex, we agree that mirror writing is "normal" to the left hand, we must consider the inhibition of this property by the attention as "abnormal". Hence the answer to the query depends upon which of the processes we choose to call the "normal" control

My experience has led me to consider both the reversed

and the ordinary script, or neither of them, to be "normal" and for the following reasons:

(1) Mirror-writing is for the left hand the simplest, most direct, and essentially the automatic motor expression, involving *only* the primary central motor apparatus. It is, therefore, the "normal" motor automatic script.

(2) But the fact of its "abnormal" appearance, both to the eyes, after it is written, and to the perception of the writer during the act, makes it a distinctly "abnormal" entity.

(3) Left-handed rightward script will, according to the above, be "normal" for the higher centers, and "abnormal" for the habitual crossed motor apparatus.

(4) The knack of mirror-writing can be acquired with facility by anyone. Yet of this latent power the vast majority of mankind is unaware. But one may not argue that the ease of its acquirement constitutes normality for a process. Nor can we suppose that the rareness of a thing makes it abnormal. We may say, however, that during the periods of acquirement, we deal with an "abnormal" process, which becomes "normal" when the higher attentive control is dissociated with ease and habitually.

(5) There can be no doubt of the normality of a certain percentage of fragmentary reversals by the left or right hand by children and by unlettered adults. The confusion of the lateral relationships occurs quite naturally in the course of development. They are more "normal" than are experimentally induced reversals, or than "normally" occurring complete reversals, because the dissociation is but mementary, is less complete, and the writer is unconscious of the reversal, at least until after it has been recorded.

I would say that the fundamental perviousness of the automatic as against the attentive paths is so much a matter of individual idiosyncracy that no line may be drawn between the physiological and the pathological. The one extreme—namely, fragmentary reversals and practiced, intentional, mirror-writing—is clearly perfectly normal. The other extreme—sudden,

spontaneous, complete reversals—certainly results only from organic or functional lesions having the nature of a dissociation. While the apparatus favoring reversals is always present as a physiologically normal entity, yet the functioning of the crossed impulses indicates, in extreme cases, great nervous disorganization.

3. Experimental Relations

The simplest experimental verification for my argument is the ease with which subjects in the hypnotic trance may be induced to write mirror-wise. Charlatans have frequently taken advantage of so evident a means to impress their audience with the supernatural import of some message. Mediums and others have, doubtless in all good faith, placed this supernatural interpretation on their accidental left-handed mirror-writing, which is apt to occur in auto-hypnotic trance states. Special directions are not generally necessary, aside from insisting upon a left-handed response. Appropriate suggestions may at times be of aid; for instance, the subject should not be aware that he is writing in any but the normal form. And why is hypnosis a favorable—nay, the ideal—condition for reversed writing? The answer is at once that the response of the automatic mechanism is more completely relieved of the attentive control than in any other condition. The diffused activity of the brain is limited. The impulses, being confined to a restricted area, tend to follow faint "traces" (i. e., crossed impulses are more free to function) from which they would otherwise become deflected (by the attention) were the content of consciousness larger. All "paths", except d_i of the schema on p. 238 are occluded by the conditions of the experiment. For the same reason the "channel" d_i is "deepened and widened".* The writing will be reversed because of the identical muscular relation between it and normal writing by the right hand. Ordinarily, this relation is disturbed by the interference occasioned from the visual centre. Ordi-

*The assumption of these brain-conditions is supported by Robertson.[58]

narily therefore, the path d_1 does not function as one simple link between the writing centre and the muscles of the *left* arm, similar to the corresponding link for the right arm.

No less striking is the effect of certain drugs[19] in facilitating the production of mirror-writing. There may be some little difficulty in handling a person sufficiently influenced by the substances for our purposes, but if he be prevailed upon to write at all with his left hand we may confidently expect at least fragmentary reversions. Thus, one who was in just the proper state of advanced alcoholic intoxication refused to move his left arm in any but the reversed direction.* Other subjects, more moderate in their potations, exhibited lesser inclinations to reversals. In fact, the greater number of any tests indicated a direct relation between the degree of intoxication and the extent of the left-handed reversed responses. The more advanced intoxication favors complete reversals, while in the less complete stages of intoxication there occur few or no reversals, even of a fragmentary character. The most satisfactory stage, all considered, is one in which the shifting of the two conditions obtains. One may see beautiful illustrations of the nice balance between the two control factors that this state favors; at one moment the muscular responses are mainly governed by the grapho motor stimuli; the next moment, the patient realizes that there is something amiss and attempts to correct the error. There is an instant of confusion accompanied by random, indefinite, motions of the arm. Then the subject gathers his scattered wits, concentrates his attention upon the task of making in- intelligible signs, and for a longer or a shorter time actually adheres to this design.

Ether and chloroform† present essentially the same phenomena. In all of the drug tests I was most careful to avoid any suggestions which might lead the subject to suspect the purpose of the experiment, as the mental condition under

*See p. 217.
†See p. 219.

these drugs is one which lends itself readily to suggestion. These drugs are all narcotics. As such, they inhibit the passage of impulses through the central system, the formation of associations and of traces. "Obviously", says Robertson[58] "such drugs must tend to limit the field of consciousness to the regions most vividly stimulated . . ." What could be more favorable for our purpose? By inhibiting the passage of impulses, it would result that the commissural traces, being already formed, in however slight degree, would be more easily traversed than the potential link with the visual area. The formation of new associations is more essential to unpracticed left-handed rightward writing than to mirror-writing. This is so apparent as not to need comment, I think. With the initial attempt at left-handed centripetal writing, new "traces" must be formed, whereas we may see that "traces" conducive to left-handed mirror-writing exist with the practice of the right hand. Lastly, we have the field of consciousness limited to the left arm and the writing mechanism, i. e. the endeavor is notably motor, as the higher, the attentive, fields are the first to be depressed by the drugs.

The action of Cannabis Indica* is peculiar to our problem. It has long been regarded as especially facilitating the passage of impulses through the central nervous system. If one were a practiced mirror-writer, and it were *suggested* to him that he should use only this style with the left hand, then mirror-writing under the influence of this drug should be extremely easy. This, in truth, was exactly what occurred when I ate the hemp. But an entirely different set of influences intervenes if the impulses are not directed into the mirror-writing "paths" by some such forces as those operating in my case. The activities of the higher, attentive, or intellectual parts of the brain are increased. We should expect, then, to have the "drawing" paths for the left-handed centripetal writing more intimately connected with the motor area of the right cortex, in view of the fact that *all* paths are more easily traversed. However, in

*See p. 218.

the two cases I have been able to test, I gained, in one, almost a pure mirror-style with the left hand. The other showed considerable confusion, but wrote mirrorwise in but a small percentage of trials. No doubt the explanation lies in the peculiar dissociative action of Cannabis Indica. In the classical description of the action of the drug[70] the individual's attention is so occupied in observing the flights of his imagination, possibly revelling in the visions, or in analyzing his state of consciousness, that the motor part is left largely unhindered by the usual attentive supervision. My hypothesis is that under precisely these conditions there will be a relatively stronger predilection towards mirror-writing than towards rightward left-handed writing.

An abrupt transition to the survey of the less evident causes of dissociation is instructive. Perhaps the most impressive example of this sort is the sudden reversion of adults which may follow functional loss of the right arm. Hemiplegias have been fruitful in calling the attention of observers to mirror-writing. Instances of injury to the right arm have been noticed to precede reversals. Merely intense occupation of the right arm favors synchronous mirror-writing with the left arm. Witness the case of the telegrapher who often jotted down messages with his left hand, while tensely operating his key with his right, and who was frequently surprised at finding the written words reversed.[50] I have personally questioned forty telegraph operators, and found that not uncommonly, under similar conditions, many of them have noticed confusion in their writing, though not all of them were sufficiently interested in these confusions to remember them definitely as reversals. Now I have found, both in the published cases and by personal experience, that there is a direct ratio between the intellectual control and the amount of dissociation necessary to bring about mirror-writing. If one glances over the conditions which favor the spontaneous occurrence of mirror-writing* he will observe that there is supposed either a low grade of intelligence or a disturb-

*See pp. 201-202.

ance of the higher faculties. And this we might expect, for there is less to dissociate in the unintelligent. That is to say, we have two grades of intelligence to both of which writing is common, and both of which possess, therefore, the ability to write mirrorwise with the left hand. The circumstance that the left arm gains in skill in direct ratio to the practice of the opposite arm, i. e., to the development of the writing centre in the left cortex, will, of course, be more favorable to a better mirror-writing by the higher intelligence. But this is rendered relatively unimportant by the greater corresponding increase of the psychological content and training, which is directly antagonistic to mirror-writing. There will be, therefore, a greater number of conditions favoring an unintelligent mirror-writing. Conversely, it will be most difficult to induce the highly educated writer to reverse, but once this is accomplished, the reversals will be much more legible, complete, uniform and automatic. This is apt to be true because to get automatic left-handed writing at all we must attain more nearly that ideal property of dissociation and suggestion which is most favorable to mirror-writing. Whereas, in the unintelligent a much lower degree of dissociation and suggestion, both relatively and absolutely, will suffice. For we find that the higher we go in the scale of intelligence, the more is the purely motor expression of brain activity subordinated to some form of expression more compatible with cultivation. Mirror-writing is not ordinarily a thing which seems to intelligence to be expressive of beauty or usefulness, and is, therefore, unless by some whim or perversion, not tolerated.

But if the higher intellectual content can inhibit mirror-writing, then a reversed vision should aid in the production of reversals, for vision is a most important guide to motor expression of the psychic areas. However, the data I obtained was absolutely contrary to my expectations.* With the inhibiting visual field converted into a support of the commissural paths, the subject ought soon to orient himself, and plunge boldly and

*See pp. 226-228.

naturally into centrifugal writing with the left hand. But the reagents calmly ignored the visual element, and wrote centripetally with the left hand; and when they attended particularly to visual control, only confusion resulted, with nothing so much as indicating any actual progress at writing. In seeking for an explanation of these phenomena, which at the time of their trial apparently so completely refuted my hypothesis, I had the reagents memorize sets of simple figures and then reproduce them with the field reversed. A marked individuality was shown in the tendency to reverse the figures. The majority of subjects, however, if left to their own devices, reversed but few or none of the figures, even with oft-repeated trials. With the right hand, reversals were extremely rare; and when they occurred, they showed a tendency to persist after the prism was removed. That is, they seemed to be errors of memory rather than confusion occasioned by the reversed visual field. Errors were more frequent when the left hand was used, and did not show a corresponding tendency to persist after the removal of the prism from before the eyes.

We may infer that the "muscular" remembrance of the right hand, of right-handed individuals, is much more certain or reliable than the left. Also that the external visual element may interfere with, confuse or control the movements of the left hand to a greater extent than the right. But the latter factor is, after all, only of slight import to the motor memory complex, even in such meaningless figures as those used. The confusing prism aroused the subject's attention, warned him to avoid the unsafe visual influence and to place his faith in the more reliable memory impressions. Muscular action is in imitation of the direction of the thought. Herein, I think, lies the reason for the control assumed by the majority of subjects in voluntarily reversing their left-handed writing. After the various tests, I had every suitable subject practice this style of script. The majority sooner or later agreed that it was necessary only to keep constantly in mind the necessity for reversing the letters, or to think of the general writing direction, or to start a

letter in a reversed manner, to have the hand complete the letter with little or no attentive guidance. The attentive and the grapho-motor elements were working hand in hand. It is but another step to suppose that without sufficient attention, or with the proper kind of confusion of the attention, the grapho-motor complex may take charge and produce a left-handed reversed script.

In the writing of adults with the left hand, I see a process comparable in some respects to a certain stage in the history of the individual acquisition of written speech. Where a child, for instance, has just thoroughly learned the appearance of his letters, he devotes extraordinary attention to making his copy as nearly like the original as possible. The two processes—the visual appearance of the letter, and the tracing of a likeness of the same visual form—are so closely linked together as to be practically a unity. I carefully studied eighteen such children and observed some forty others of approximately the same grade of experience, and none of them evinced the slightest inclination to left-handed reversals. Nor could they be induced to reverse; confusion and return to the usual appearance of the letters supervened in every instance that reversing was tried. In a like manner the adult of average intelligence thinks it impossible to reverse his writing. And if he does succeed, he usually calls upon his greater experience to reverse the mental image of the visual and motor "appearance" of the writing.

At a later period, the child shows a considerable tendency to become careless. Perhaps his joy at having finally mastered the intricacies of graphic language incites him to over-confidence in his ability to write invariably a correct copy. Probably, too, the preponderating visual control has been somewhat replaced by the automatic system of writing, which is closely linked on the motor side and but feebly bonded on the visual side.* It is then quite easy to throw the child off his guard and secure whole words in mirror form. I found in a preliminary study of eight children of this age that some simple sub-

*See pp. 238-241.

terfuge such as having the child write rapidly two closely connected words, for instance, "Berkeley, California", or the date, (but, between the words, having the paper turned rapidly about through an angle of 180° in its own plane), was often sufficient to cause the second word to be reversed.* A specialized confusion is aroused, with as little introduction of absolute suggestion as may be.

It will perhaps be advisable to consider a few of the published cases of mirror-writers which may not seem compatible with my argument. Type case: E. M., a paralytic imbecile girl of seven years, hemiplegic since birth; when learning to write with the left hand, she persistently produced mirror-writing.[38] Compare such cases of left-handed children learning to write with the interesting report of Kingman.[42] A teacher injured her right hand. She easily wrote mirror-wise with her left hand and found it more convenient to give copy to her pupils in this style till she recovered. The children used a mirror to read their copy. Three of these children were examined by Kingman and found capable of mirror-writing with either hand, easily and rapidly. There is a ready explanation for these occurrences of mirror-writers quite aside from the interpretations that might be drawn from the consideration of a possibly altered central motor complex. The tendency for children to mimic the motions of others is proverbial. I have had occasion to observe this inclination in a large number of cases. The average child will blindly follow any movement of one in authority, thinking, no doubt, that it is all a matter of the queer, grown-up idea of propriety, to be adopted without question by the child. This is especially true of deaf children, who rely more upon vision and who are more apt to subordinate other faculties in their endeavor to follow the meaning of their instructor. Even more would this be true in the imbecile attempting to imitate obvious graphic signs ([65], p. 83). There have been cases reported where defective sight was associated with the mirror-writing of children. In one instance, upon

*See p. 223.

removal of this reflex irritation, the writing at once became rightward, and if the corrective glasses were removed the writing was again mirrorwise.[64]

Now, the centrifugal direction, being the biggest and most easily grasped feature of writing, is apt to be seized upon first by the child, especially if sentences rather than letters are used. The child is imitating with his left hand a series of motions made by the right hand of the instructor. Then, too, the symbols which the instructor forms have very little meaning to the child who is just learning to write, hence his reversal of them will have little or none of the unusual in their appearance. If the child is allowed to continue to practice the reversed form, it will become habitual, which will mean merely that he has learned his letters in reversed form. Ordinarily this process is not allowed to continue to such an extreme. Occasionally however, this does occur, as is shown by several cases where reversed writing could be quite fluently read.* As such cases are able to read ordinary writing, it would seem that they have simply acquired an additional alphabet-complex in their reading centre, by which they are enabled to interpret mirror-writing. It is not necessary to assume a visual disarrangement of any sort to enable one to read mirror-writing, since all who are able to do so either are mirror-writers, or have had experience with mirror-writing. Without this experience, which must be quite extensive, the person will find it necessary to run his eye backward over a word, thus deciphering every movement as it was made when forming each letter.

The different central relations that might be noticed in the various writing combinations of the left handed, and various ambidextrous tests, form a tempting subject. But this is a question which I have been careful to avoid as beyond the scope of my problem. At best, a consideration of these relations could but lead us further into the field of the hypothetical. However, I may mention the following as a possible explanation

*Most congenital mirror-writers can read reversed writing fluently.[12] Most cases are unable to realize the copy as different from the text.[64]

of why there is a greater tendency for the left-handed child to write mirrorwise with the left hand, than there is for the right-handed child to write mirrorwise with the left hand. In the left-handed, the seat for the development of a centre for written speech is presumably in the right cortex. But the child is not allowed to use his left hand for purposes of writing. We should remember that upon the use of the right hand for ordinary writing depends our ability to write mirrorwise with the left hand. Now the language-complex in the present case is such that we may suppose the writing impulses are carried from the right cortex to the emissary area of the left cortex and thence to the right arm. An extra step is added. Hence, if the child does occasionally use the left hand, this extra step will be dropped. His left-handed writing is therefore simpler than the left-handed writing of a right-handed individual. Accordingly there is a greater tendency for the impulses to function unaltered in the left-handed child. What seems to me to be a confirmation of this opinion is given by Hughes[33] in a report upon his own experience. He was congenitally left-handed but was taught to write with his right hand. He was troubled for a number of years by the difficulty he experienced in so writing. Finally he hit upon the device of writing everything with his left hand mirrorwise, on thin transparent paper, and turning these sheets over when he wished to read them. Left-handed mirror-writing obviated all the tediousness of rightward right-handed script. I postulate that a writing-centre was developed by the right-handed practice; that left-handed rightward writing would necessitate reforming this complex into entirely different relations; and that the primary facility of left-handed use tipped the scales in favor of an automatic, rather than of an attentive control. Any double-centre hypothesis (which Hughes himself favors) would be inadequate, because if there was a separate centre in the left cortex, it would be this centre which would be more highly developed by practice of the right hand; the "overflow" into the right cortex would be relatively less, and the difficulty of writing automatically with the left

hand would be greater instead of less than that of the right hand, in spite of the fact of left-handedness.

While there is probably some such contributing factor as that outlined above, the safest and best explanation lies in the simple fact that the left arm of the left-handed child is the one preferred for all of the delicate operations ordinarily performed by the right hand. Use of the left hand for writing will therefore be a more thoughtless, a more automatic, reaction than a similar action by one who is right-handed. And an automatic writing presupposes a proportionate increase in the control of the motor complex of writing; which in turn, is more favorable to reversed writing. It is a necessary condition that the child must have had some practice with his right hand at ordinary writing. Otherwise, there will be no reversals by the left hand, for those who have been allowed to use their left hand freely and from the first, find rightward writing as easy as do the right-handed.

There is an interesting question opened here, which I unfortunately have thus far been unable to investigate satisfactorily. That is, will left-handed writers, when placed under the same conditions which favor a left-handed mirror-writing by the right-handed, produce mirror-writing with the right hand? According to my argument they certainly should. Obviously the experimental difficulties would be far greater. Thus, it is a difficult matter to find left-handed writers who have not at some time been forced to practice right-handed writing. Such practice would, of course, introduce a new element into the writing complex, and make these subjects unamenable to corresponding tests given the purely right-handed or left-handed writer. Of numerous left-handed persons investigated, but one could claim entire freedom from attempts to enforce the use of the right hand. The right-handed writing of this reagent was subject to experimentally induced reversals in a manner analogous in every respect to the left-handed writing of right-handed individuals. That is, suggestions as to the purpose of the investigation were as carefully avoided, the tests were

similar, and reversals were as easily elicited as in the average right-handed subject. I found greater average difficulty in getting a right-handed reversal in those who had in the past practiced somewhat with the right hand. This I attribute to the fact that it is relatively a more automatic process for them to write rightwards with the right hand, due to the practice they have received in this action. Carrying this division to its extreme, we have those who have learned to write correctly with the left hand, but have subsequently been "broken" and trained in the use of the right hand. They are especially unlikely to give any clear-cut, consistent, spontaneous reversals by either hand. It seems not improbable that these individuals have developed two writing-centers, one for rightward left-handed writing which, according to my argument, would lead to right-handed mirror-writing; and one for rightward right-handed writing. Such a case is given by Acke[illegible] boy of ten years, broken of left-handedness, who wrote with equal facility in four different ways, viz.: mirror-writing with either hand and rightward writing with either hand. I experimented on two left-handed children who were being "broken" and found it an easy matter to develop them into similar cases.

Let us consider also those instances where there is a permanent injury to the right arm, and an acquired facility in rightward left-handed writing. The writing is at first a slow, labored, attentively controlled "drawing", typical of the ordinary left-handed attempt at writing. But this improves rapidly, and the writing comes to have much of the automatism characteristic of ordinary right-hand writing; yet is seldom, if ever, as completely automatic. Separate "centre" for mirror-writing is hence superfluous, and is probably not formed, although an additional centre for left-handed left-to-right writing requiring as it would an entirely new set of kinesthetic responses may presumably be formed by practice.

4. Recapitulation

My argument may be summarized as follows:

Mirror-writing depends upon two conditions. The one is the physiological element which embraces (a) the same single grapho-motor memory centre for written symbols that is employed for ordinary right-handed writing, and (b) the identical sensory-motor relation that left-handed reversed writing bears to right-handed rightward writing. Hence there is a predisposition towards unpracticed left-handed mirror-writing which exists coextensively with the ability to write with the right hand. There exists no such complex for left-handed centripetal writing. Mirror-writing is a relatively rare phenomenon. Therefore, it must depend upon the *disturbance* of some part of the writing apparatus other than the motor; for the integrity of the grapho-motor centre and the commisural paths is the very foundation upon which mirror-writing is based. This is the second condition, the psychological element. The psychological governor which supervises our ordinary writing, must be so rearranged or altered that the psysiological provision for mirror-writing is given an opportunity to act, or, perhaps, is encouraged or stimulated to independent action.

The most striking generalization to be drawn from observations on mirror-writing is that even in the most favorable conditions for mirror-writing there is a great deal of individual variation; that is, in any condition, such as hypnosis, one subject will write entirely mirrorwise, while another can scarcely be induced to write at all in this style. I find exactly the same relation in the description of those cases which occur spontaneously. The pathological conditions mentioned on pp. 201 202 are relatively common. Yet mirror-writing is so rare as to cause immediate comment whenever it occurs. This may be due to the fact that only infrequently do these patients attempt to use the left hand for writing, in which case mirror writing could be expected in every instance when these patients were asked to use the left hand. Or, it may be that there is some

particular disorganization which occurs inconstantly in all of the conditions favorable to mirror-writing. And this in truth more nearly approaches the conditions which my own theory emphasizes. The more that the psychological, or higher, parts of the nervous system are disorganized, the more confidently may we expect a left-handed reversed writing to result. Again, the disorganization must be great enough to pass a certain minimal limit before one may expect spontaneous, complete left-handed reversals. And more particularly, we may expect that if the disorganization is of a specialized kind, one that will dissociate the automatic from the sensory and attentive control of the muscles, or, a step more, divert writing activity to the physiological element, the dissociation need be much less than if the disorganization is general. This is observed particularly when considering the relatively circumscribed disturbance occasioned by the majority of my experiments,* as against the great disorder of many of the pathological states in which mirror-writing occurs, notably the insanities.

There are two additional forms of left handed mirror-writing -- viz., the deliberate, intentional, attentive and the fragmentary. These also depend, but to a much less degree, upon the crossing of the secondary impulse. In the first of these forms, the less conscious or intentional the mirror writing is, the greater is this dependence. Conversely, the more attention we devote to these movements, which are a new experience to our higher consciousness, the more dependence is placed upon the visuo-psychic and association areas for guidance. In the second type, there is a tendency for some reagents to make fragmentary reversals with the left hand, which depend to some extent upon the commissural paths, but as the reversals are, with lower grades of experience, frequent with the right hand, the ultimate explanation is found in the confusion of lateral relationships. This type can not properly be considered as a representative of true mirror-writing.

*See pp. 215 ff.

PART IV

RELATION OF CONCLUSIONS TO EARLIER EXPLANATIONS

Referring to the classification of previous hypotheses as given on page 214 I find that while the definitions of the occurrence of certain tendencies in movements are perhaps true, Group A does not comprehend the fundamental reason for mirror-writing. Of this group, the observations of Durand and Peckham strike nearest to the real cause of *mirror-writing*, in that they introduce quite prominently the factor of attention; Peckham including as well a physiological basis for the phenomenon.

The criticism of Groups B and C are several, and may be best made clear by referring to the observations which seem to favor the hypothesis of a single centre,* and in addition to the criticisms of Hale and Kuhl† and of Sweeney‡ I have shown that it is possible to escape from the wholly unsatisfactory idea of the presence of a definite mirror-writing centre; and that the theory, rather than suffering from this omission, is actually rendered the stronger. The study of these groups brings out a matter of even greater moment, namely, that the physiological aspect of mirror-writing, however it be answered, is but a minor part of the solution of the question.

With the observations classed as group D, I agree. However, the same criticism as was made of group A applies here—the explanation is not sufficiently comprehensive. In every case of true mirror-writing (which it should be remembered, does not include reversals by the hand accustomed to writing) there must be a disturbance, a deflection, of the mental content, a dissociation of attention.

Group E, in placing prominence upon a factor of visual imagery, neglects the proper significance of the normal physiological, or grapho-motor, element as being the fundamental

*See pp. 227-237, also group D, pp. 210-211.
†See pp. 211-212.
‡See pp. 212-213.

means by which true mirror-writing is accomplished. I agree with the conclusion of Hale and Kuh on fragmentary right-handed reversals, but do not class this type as a representative of true mirror-writing. I cannot agree with their, or with Sweeney's answer to the question, why mirror-writing is not inverted: though their observations are sound, and are sufficient to account for right-handed reversals, yet the motor relations as I have described them would not permit of true inverted writing.

I agree with Downey in group F, that there is a motor as well as a visual representation of a movement. My experience has been that the majority of subjects, when voluntarily reversing their writing, exercise their attention principally to force the writing in a *reversed* direction. The actual reversal of the letters is by the guidance of the grapho-motor system. Attentive guidance is required only when a confusing or relatively unfamiliar letter brings uncertainty to the automatic control.

Many of the earlier explanations seem to be devised in view of the special conditions offered by some particular case of mirror-writing. Explanations of different observers have therefore differed widely. I have shown that all the reported causes of mirror-writing, or conditions favoring it* have characteristics in common. Further, I have shown that typical mirror-writings can be controlled by experimental methods, and that to study mirror-writing we do not need to seek the spontaneously occurring cases, as has been done in the great majority of reports. Lastly, I have shown that mirror-writing is a simple, direct and unified process, not at all as complicated and disconnected as a comparison of the several findings would lead one to expect. Its explanation is simply that certain impulses which do not ordinarily function, are by the conditions in which mirror-writing occur allowed to do so. These conditions, instead of being a more or less unconnected set of symptoms as indicated on pp. 201-202, I have shown to rest, with the experimental conditions, upon the common basis of dissociation.

Transmitted June 20, 1914.

*See pp. 201-202.

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IN
PSYCHOLOGY

Vol. 2, No. 4, pp. 267-275 May 2, 1916

MEMORY AND ASSOCIATION IN THE CASE OF STREET-CAR ADVERTISING CARDS

BY

WALTER S. HELLER AND WARNER BROWN

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

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The primary object of this experiment was to obtain a record of the association, and if possible the very first association, which is aroused upon glancing at an advertisement. The material consisted of sixty advertising cards of the kind generally displayed in street cars. These cards, which are 22 inches long and 11 inches high, were hung upon a rack at about the height and distance of their usual position in a car and so arranged that they could be displayed one at a time. They were illuminated by a combination of daylight and shaded electric light. A curtain was arranged to give a uniform background around the card and to conceal the apparatus and operator.

The cards were selected from a large collection, all of which had been recently displayed or were being displayed in the local street cars. There were cards of a great variety with respect to color, typography, and subject-matter. An effort was made to have the same number of cards making special appeal to men as to women.

The associations were recorded by means of a special form of phonograph (the dictaphone). This was so arranged that it was set in motion at the moment a card was displayed, and was stopped soon after the observer had spoken. At the same time the phonograph recorded the half second beats of a metronome, so that upon subsequently listening to the record one could measure the lapse of time between the exposure of the card and

the reaction word. Each card was exposed about 5 seconds after the completion of the preceding reaction. Some persons tended to react with rather complicated sentences from which it was difficult to extract the essential idea; on that account it was found necessary to have the reaction limited to a single word, which is generally the spontaneous mode of reaction.

The persons who made the observations were fifty men and fifty women, student volunteers, most of them untrained in such work. They had no knowledge of the purpose of the experiment other than that conveyed in the directions.

A set of typewritten directions was handed to the observer, as follows:

> It is the purpose of this experiment to find out just what ideas are brought up by different advertisements.
>
> Each advertisement will be exposed for a few seconds, a very short time. Within this time, and in fact just as soon as you possibly can, you will say what the advertisement makes you think of.
>
> Give only one word. It must be the very first idea that comes into your head.
>
> The word you give may be some personal experience of which you are reminded, it may be something you know about the goods or firm, it may be something you have heard, it may be an expression of your personal feelings or of a momentary impression, or it may be wholly irrelevant.
>
> Do not reject any idea that comes up, even though it appears to be foolish.
>
> Speak out very loud and very distinctly. Pitch the voice as low as possible. Hold the mouthpiece close to the lips.

The observers were allowed to practice somewhat with the phonograph in order to relieve their diffidence. Furthermore, the first ten associations were used merely for the sake of practice and were discarded, but without the knowledge of the observer.

A memory test was made as soon as the association test was completed. It will be noted that the memory would cover sixty cards, although only the last fifty appeared in the record of associations. Items in the memory record referring to the first ten cards were therefore discarded in computing the association test. The directions for the memory test were as follows:

Write down the names of all the advertisements that you can remember of the series just shown you. Enter the item under one of the three heads, according to what you remember, and then fill out as much as you can under the other heads, opposite the same number:

(1) Kind of thing advertised;

(2) Name of maker, brand, trademark, company, etc.;

(3) Special features remembered.

It is important to note that in tabulating the data obtained in the memory test an equal weight is to be assigned to any entry under any one of three heads—A, B, or C—to be explained later. Thus credit for three points was given if an observer remembered all three essential facts about a card, namely, what is advertised, who advertised, and how advertised. The data are reported in percentages; thus the score of 69.3 per cent made by the person with the best memory means that she was able to report 104 of the possible 150 items concerning the 50 cards for which records were retained. The score for any given card is found by adding together its entries under all three heads for all the observers.

The cards were always displayed in the same sequence, which was determined in the first place by chance. The cards at the end of the series are generally remembered somewhat better than those at the beginning, as evidenced by the fact that the correlation between lateness in the series (recency) and success in recall is 0.35. Yet the cards themselves appealed to memory far stronger than did their position; the five cards best remembered had the following positions in the series: Onyx Hosiery, position number 41; Arrow Collars, number 11; Hart, Schaffner & Marx, number 43; Haynes Automobile, number 39; Spearmint Gum, number 1. It should be noted that these position-numbers refer to the last fifty cards only, as the data from the first ten cards, used for practice, as already said, are not considered; thus Spearmint Gum was the first of the fifty, but was actually the eleventh card shown. None of the first ten practice cards was recalled as often as Spearmint Gum, but the seventh of them, Walkover Shoes, was a very close rival.

The data from the memory test have been used chiefly in correlation with other data to be given later on, but there are certain sex differences to be noted which are of interest, and perhaps of further significance. Under the heading which is least explicit, A, "the kind of thing advertised," the women excel the men to a greater extent than under the more explicit headings; the women report 27.4 per cent of the items, the men 23.9. The best advertisement under this heading for both sexes is Onyx Hosiery; 80 per cent of the women give "hosiery," "stockings," or "socks," while 74 per cent of the men give these words.

Heading B requires the most explicit information, the essential fact of the advertisement, namely, the name of the maker, brand or trademark. Men and women are here equal, both reporting 16 per cent of the possible items. The women remember best Arrow Collar, 62 per cent of them giving the name. The men recalled best the name Haynes Automobile; 56 per cent of them gave this.

Under heading C, which calls for some feature of the advertisement itself rather than of the thing advertised, the memory of women is again better than that of men. The women retain 23 per cent of the possible items, the men 21 per cent. Special features of Arrow Collar and of Hart, Schaffner & Marx Clothing (the best advertisements for women under this heading) were remembered by 58 per cent of the women. Both of these advertisements contained pictures of young men. The Hart, Schaffner & Marx advertisement is also the leader with the men observers under this heading; 52 per cent of them remembered it.

In general, the memory of women is better for the advertisements than that of the men. But this is not true in particular instances. They do not remember the essential business factor, i.e., the *name* of the advertiser, any better than do the men. And while they excel the men in the case of 31 cards, there are 19 cards which are remembered better by men than by women.

The study of association of ideas in this case follows two lines: the measurement of reaction time and the classification

of the associations into types. The types in this case were determined with a view to the practical requirements of the business of advertising after an inspection of the actual words given by the observers.

1. *Reading.* When the observer merely read off from the advertisement, obtaining his ideas directly from the type or picture, the ideas were classified as "reading." For example, the word "stocking" from a hosiery advertisement.

2. *Competitor.* If an observer gave the name of some other product or producer in the same class the word was classified as "competitor," and a sub-class was made for reactions giving the name or trademark of another advertiser in the same line of goods.

3. *Personal.* This class includes all the terms which seem to relate only to the personal experience of the observer, for example, "Myself," "Camping Trip," "Home."

4. *Emotional.* Any expression which gives voice to a feeling or implies an emotion, such as "Foolish," "Good," "Bad," is included in this class.

5. *Objective.* The reactions included in this class are those which express a normal, obvious relationship in the subject matter between some aspect of the advertisement and something else; but one which would not be included in any of the other groups. For example, the advertisement of Heald's Business College provokes the reaction, "Bookkeeper."

6. *Unknown.* A caption employed when no association could be traced and yet it appeared probable that one really existed in the mind of the observer.

7. *Nothing.* This caption covers not only those rare cases in which no response was made but also those in which the response appeared to be quite meaningless or irrelevant. Under this head come the reaction words given by the observers when they felt constrained, by the lapse of time, to say something, but could think of nothing that seemed sensible. Such associations are too profound for analysis in such a study as this.

Doubtless the distribution of the associations under these

captions occasionally was arbitrary, but in many doubtful cases observers themselves assisted in defining the meaning of their expressions, and in all cases the writers were in agreement as to the classification.

In addition to the classification of associations given above, another method was adopted based on the point of view of the practical advertiser. Associations were called "favorable" or "unfavorable": "favorable" if they were such as to indicate a favorable attitude toward the advertiser; "unfavorable" if they tended to his disadvantage. Thus, items under "reading" are "favorable" if what is read is relevant to the advertisement; "unfavorable" if some wholly irrelevant feature is noted, such as the name of a bank represented in an automobile advertisement. The class "competitor" is naturally all unfavorable. "Personal," "unknown," and "nothing" are neutral, but "emotional" can be clearly either favorable or unfavorable. "Objective" associations are called favorable unless there appears to be something in them to the disadvantage of the advertiser.

The reaction times are sufficiently short to warrant the assumption that the reported ideas lay very near the surface. Men respond more quickly than women: partly, it seems, because they give more "reading" associations; 54 per cent of their associations are "reading" compared with 43 per cent for the women; partly because they experience less embarrassment in talking to the phonograph; but chiefly because they respond more spontaneously. Women partly defeat the purpose of the experiment by unconsciously or consciously selecting their associations. This is shown not only by their distinctly slower reaction time but by the fact that their associations cover a considerably wider range of ideas than those of the men. This fact was ascertained by listing all the words given by all the men (or women) in response to each card. The average card gave rise to 27.6 different ideas among 50 women, but to only 22.6 among the same number of men. The women had more different ideas per card than the men in the case of 45 of the 50 cards.

The reaction times (for 50 cards) for women range from 1.3 seconds to 7.2 seconds, average 3.3 seconds, median 3.3 seconds. The reaction times for men range from 0.9 seconds to 6.2 seconds, average 2.5 seconds, median 2.3 seconds. Men have a more rapid reaction for all but three of the 50 cards. Thus it is evident that the women hesitate longer over their responses and differ more from one another in their responses.

For the advertising world the significant thing about the reaction times is that some advertisements produce an audible response much more quickly than others. Thus an advertisement of Coca Cola, Heinz, or Schilling's Best, all good cards and familiar, will provoke a response on the average within 2.2 seconds, whereas some of the poorer advertisements require as long as 3.7 seconds for the average person. In general, an advertisement which produces rapid reactions with one sex is equally successful with the other.

The classification of the associations also throws a strong light on the advertising value of the particular cards. Associations which are favorable to the advertiser are frequent with some cards and infrequent with others. Thus the extremely simple card of Schilling's Best gives 88 favorable responses per cent, while another card gives only 26. Some cards give a large number of "reading" responses in which the observer indicates that he has apprehended directly what is presented to him has been "hit." Thus Spearmint and Coca Cola are read off by 67 and 60 per cent, respectively, of the observers, while Schilling's Best, although it consists of only the two words in type without embellishment, is read off by only 11 per cent, and "Perfection Bread" by only 4 per cent of the observers. Note, however, that the 67 per cent "reading" in the case of Spearmint was all of relevant facts and therefore "favorable," while half of the Coca Cola cases of "reading" noted wholly irrelevant or "unfavorable" matters, such as an unimportant fact about the girl in the picture. In the same way "objective" associations leading from the card to something naturally suggested by it are very common with some cards, being 75 per cent of the responses for

Schilling's Best or Perfection Bread; and are rare with others, being for Spearmint only 13 per cent. "Emotional" responses are not produced freely by any of the cards, but "personal" words rise as high as 14 per cent in the case of Daggett & Ramsdell's Cold Cream, or up to 17 per cent in the case of the advertisement for the Dictaphone, used in the experiment. Responses "unknown" and "nothing" are a pretty clear indication of bad advertising; the Hoosier Cabinet was the worst in this respect, giving 11 per cent of such responses, although, strange to say, Spearmint came next with 8 per cent.

Advertisements which advertise something other than what they are intended to advertise, or even a direct competitor, stand in a class by themselves. The card of a local lumber company was mistaken for an advertisement of something else by 18 per cent of the observers, and the card of a local confectioner caused 9 per cent of the readers to mention some other confectioner. In this connection it may be mentioned that a similar confusion sometimes appears in the memory test; for example, half of all the observers who mentioned corn-flakes at all, put down Kellogg's, which did not appear in the actual series; although "E. C." did. This mistake was made by 12 per cent of all the persons.

The unfortunate confectioner whose card was just mentioned as having aroused the name of a competitor as a reaction word was remembered by only 15 per cent of all the observers, and to one-third of these it recalled a competitor who did not appear in our list.

Statistical treatment of the data shows that there is a close relationship between the results of the memory test and the speed of association. It might be thought that a slow reaction time, involving a comparatively long time of exposure, would help the memory, but such is not the case. Those cards which are responded to the most quickly are best remembered. The correlation[1] is 0.42 for the women and 0.45 for the men. Probably the factor of previous familiarity is responsible for some part of this correlation.

Certain mechanical features of the advertising cards were

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[1] Computed: $r = 1 - \frac{6\,\Sigma D^2}{n\,(n^2 - 1)}$

also measured and the data correlated with the psychological data. The cards were given a position in rank according to (1) the proportion of the card taken up by the cut, (2) the size of the largest type employed in the wording, (3) the total number of words printed on the card. Correlations of memory are:

	Women	Men
With amount of cut	0.394	0.200
With size of letters	0.118	0.141
With number of words	0.136	0.223

That is to say, a card will be somewhat better remembered if it has a large picture and if the number of words is small; but the size of the letters is an unreliable factor.

The correlations between rapidity of response in the association test and these mechanical factors are:

	Women	Men
With amount of cut	0.271	0.101
With size of letters	0.282	0.052
With number of words	0.322	0.182

In other words, the same factors which help memory help to accelerate the association, namely, large picture and few words, and in addition it appears that large type is probably helpful. There seems to be a close link between rapidity of response in association and facility of recall in memory. For the writer of advertisements this means security from an imaginary danger; an advertisement which has speed will not be in danger on that account of being forgotten; on the contrary, the very factors which make it fast, even the purely mechanical factors of large picture and few words, will help to hold it in memory.

A further indication of the close relationship between memory and good composition in the advertisement is to be seen in the fact that there is a positive correlation between memorability and frequency of "favorable" associations (0.16) and a corresponding correlation with the absence of "unfavorable" associations (0.28).

These experiments were performed in the Psychological Laboratory of the University of California during the fall of 1914. The original cards and completely tabulated data are on file in the laboratory and may be consulted there.

Transmitted January 17, 1916.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
PSYCHOLOGY

Vol. 2, No. 5, pp. 277-290 May 4, 1916

A COMPARISON OF THE JAPANESE FOLK-SONG AND THE OCCIDENTAL

A STUDY IN THE PSYCHOLOGY OF FORM

BY

SANGORO ITO

UNIVERSITY OF CALIFORNIA PRESS
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PSYCHOLOGY

Vol. 2, No. 5, pp. 277-290 May 4, 1916

A COMPARISON OF THE JAPANESE FOLK-SONG AND THE OCCIDENTAL

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BY
SANGORO ITO

The folksong in Japan differs from the Occidental, in that it plays no important part in the home life of the people. It is mainly used out of doors, in the season of cherry blossoms, of maple leaves, and in other rural festivals. A great many Japanese songs are licentious in meaning. The traditions of the Japanese folksong carry us back as far as 901 A.D. (Engi Era), when it is believed that under the imperial patronage the national dance with great varieties of songs developed on a basis of peasants' songs sung as the men trudged over the mountains with pack-horses bringing tribute to the Emperor.

The following are two verses of such a song:

Ide waga koma wa
Hayaku yuki-hose Matsuchi yama,
Aware Matsuchi yama ware.

Ao-yagi wo
Kata-ito ni yorite ok'e ya
Uguisu ni ok'e ya.

The translation:

Oh, my pony,
Hasten past the Matsuchi Mountain;
Oh, fair Matsuchi Mountain!

Weeping willow tree,
Twist thy single silken strands into a perch
Whereon the nightingale may perch.

Later the spirit of daily occupations reduced the songs to regular forms. Thus, there is *Mari Uta*, "Song of the girls playing at ball," and *Usu-hiki Uta*, the "Mortar Song," sung by two girls pounding rice or beans in a mortar to the rhythmical beat of the pestle. Then there is the famous *Bon-Odori Uta*, (*Bon* is the Memorial Day of the Ancestors, held at the full moon of July). Again, the same idea led to the many charming songs invented to accompany the Geisha dances of the present day.

The seventeenth century introduced a novel composition known as *Ha-Uta* and *Ko-Uta*, short poems or proverbial sayings. Both emanated from the *Utai* (the song part) of the classical *Sarugaku*, or popularly known *Nō* dance, and the *Jourori*, recitative accompanied by solemn open chords.

The local spirit is woven into these songs. The majority of the songs that have been selected for the present study bear the name of the localities in which they originated, usually the districts formed by clans, rather than the names of villages or towns. Primitive as the state of Japanese civilization has been, the spreading of these from one place to another recalls many romantic incidents in the life of the people.

EXPLANATION OF SYMBOLS USED

In the notation given on the following pages, the letters A, B, C, etc., represent *phrases*. *A* is arbitrarily assigned to the first phrase in a song; B is another phrase different from A; similarly C differs from either A or B. But in case the second phrase is but a slight modification of the first, and is not different enough to warrant its being called B, then such a phrase is designated by A′; for this same reason B′, is a modification of B.

The phrase is sometimes divisible into equal portions called strains, and the strain into equal portions called motives. Sometimes strains and motives appear within a song as a thematic

repetition or as a refrain, and in such cases either *l*, *m*, or *n* is used above the capital letters to denote them.

The Arabic numerals 1, 2, 3, below the capital letters denote the number of measures in the phrase.

As signs of repetition, : : are used.

I indicates an instrumental introduction in the Japanese songs, containing a theme of the song or the suggestion of a theme.

i indicates an instrumental introduction without theme or suggestion.

— indicates a bar or measure occurring within a song purely as an instrumental part and without words.

ex. is used to indicate exclamations, as explained under Japanese songs.

Any song having two distinct sections, whether the sections are phrases, periods, or sentences, is regarded as having a "binary form"; similarly, any song of three sections is regarded as having a "ternary form."

The first column in the following classification indicates the musical metre of the song; the second column, the structure; the third, the name; and the last, the country to which it is commonly attributed.

OCCIDENTAL SONGS[1]

Two Section Structure, or Binary Form

Metre	Structure	Name of the song	Country
$\frac{2}{4}$	(A A B B') (A A B B') 3 3 3 3 3 3 3 3	The Sacrifice	Russia
$\frac{2}{4}$	(A A') (B C) 4 4 4 4	Annie Laurie	Scotland
$\frac{4}{4}$	(A A') (B C) 4 4 4 4	John Anderson, my jo	Scotland
$\frac{3}{4}$	[(A B) (A B)] [(C C'') (A B)] 2 2 2 2 2 2 2 2	Last Rose of Summer	Ireland
$\frac{2}{4}$	(A B) (C A) 4 4 4 4	Ancient March, from Dalecarlia	Sweden
$\frac{6}{8}$	(A A) (B A) 4 4 4 4	Drink to Me Only	England

[1] Professor Charles Louis Seeger, Jr., of the Department of Music of the University of California has kindly assisted me in the selection of the Occidental songs, and aided me on the musical side of this study.

Metre	Structure	Name of the song	Country
$\frac{4}{4}$	(A B) (B A) 2 2 2 2	Fair Maiden's Beauty	Ireland
$\frac{4}{4}$	$(\overset{m}{A}\ A')\ (\overset{m}{B}\ A')$ 4 4 4 4	Captain Thompson	Ireland
$\frac{4}{4}$	(A A) (B A) 4 4 4 4	All Thro' the Night	Wales
$\frac{4}{4}$	(A A′) (C B) 2 2 2 2	Comin' Thro' the Rye	Scotland
$\frac{3}{4}$	(A A) (B A) 4 4 4 4	Saeter Song	Norway
$\frac{3}{4}$	(A A′) (B A′) 8 8 8 8	Serenade	Spain
$\frac{2}{2}$	(A B) (A C) 4 4 4 4	Idle Hours	Italy
$\frac{3}{4}$	(A B) (A B′) 4 4 4 4	Back in the Time When My Grandfather Wed	Germany
$\frac{3}{4}$	(A A) (B A) 4 4 4 4	Hemlock Tree	Germany
$\frac{6}{8}$	(A A) (B B′) 4 4 4 4	The Orange Tree	France
$\frac{6}{8}$	(A A) (B A) 4 4 4 4	Hunting the Hare	Wales
$\frac{6}{8}$	(A A′) (B A′) 4 4 4 4	The Homeward Way	Croatia
$\frac{3}{4}$	(A B) (A′ B) 4 4 4 4	When Love is Kind	Ireland
$\frac{4}{4}$	(A A) (A′ A″) 4 4 4 4	The Lowland of Holland	Ireland
$\frac{3}{8}$	(A A′) (A A′) 4 4 4 4	La Cachucha	Spain

Binary Form, With or Without Repeats

Metre	Structure	Name of the song	Country
$\frac{4}{4}$	(A A′ B C) (D D E C) 2 2 2 2 2 2 2 2	The Campbells Are Comin'	Scotland
$\frac{4}{4}$	(A B C D) (A′ B′ C D) 2 2 2 2 2 2 2 2	Loch Lomond	Scotland
$\frac{3}{4}$	$(A\ \overset{m}{B})$:(C C′): 4 4 4 4	The Sheep in the Snow	Isle of Man
$\frac{3}{4}$	(A B B) :(C B B′): 4 4 4 4 4 4	Mazurka	Poland
$\frac{2}{4}$	:(A A) (B A′): 4 4 4 4	Rustic Dance	Bohemia
$\frac{3}{4}$	:(A A) (B A′): 4 4 4 4	Love's Parting	Russia

Binary Form with Extension

Metre	Structure	Name of the song	Country
4/4	*m* *m* (A B) (B′ C)+D 2 2 2 2	Come All You Maidens Wherever You Be	Ireland
3/4	(A A) (B C)+C 4 4 4 4 4	Dalecarlian Maiden's Song	Sweden
3/4	A B+B′ 8 8 8	Santa Lucia	Italy
6/8	(A A) (B C)+C 4 4 4 4 4	Louisella's Garden	Italy

Three-Section or Ternary Form

Metre	Structure	Name of the song	Country
2/4	A B B 4 4 4	Winter	Russia
3/4	*m m m* A A B 8 8 8	With My Flock	England
4/4	A A (B B) 4 4 2 2	Lullaby	Ireland
3/4	A B B 5 5 5	Troika	Russia
2/4	A B C ABC	The Scarlet Sarafan	Russia
6/8	(A B A′ C) (D D) (A B A′ C) 2 2 2 2 2 2 2 2 2 2	For He's a Jolly Good Fellow	England
2/4	:(A B): C (A B′) 4 4 4 4 4	Vermeland	Sweden

Ternary Form with Extension

Metre	Structure	Name of the song	Country
3/4	(A A) (B B) (C C)+C′ 4 4 2 2 2 2 2	Necken Polka	Sweden
3/4	*m m* A A B+*m* 4 4 4 2	Home Forever	Norway

Combinations: Verse and Chorus or Refrain

Metre	Structure	Name of the song	Country
2/4	*n mn mn′ mn* (A B) (C B) 4 4 4 4	Auld Lang Syne	Scotland
4/4	(A A B A) (C A) 4 4 4 4 4 4	The Vicar of Bray	England
3/4	(A A) (B B′)+A 5 5 5 5 5	A Spanish Gypsy	Spain
4/4	(A A B B) (C B) 4 4 4 4 3 4	Home, Sweet Home	England

COMBINATIONS: BINARY OR TERNARY WITH BINARY AND REPEAT

Metre	Structure	Name of the song	Country
6/8	A A′ (B B)+A A′ *Da Capo*: 4 4 2 2 4 4	Duke Marlborough	France
3/4	(A A′A B) :C D: (A A′A B) *Da Capo*: 4 4 4 4 4 4 4 4 4 4	Song from the Pyrenees	Spain
2/4	*m m m* (A B A) :C D: 4 4 4 4 4	The Gypsy Forge	Hungary

THE CLASSIFICATION OF THE JAPANESE SONGS

In the classification of the Japanese songs there are many things that should be explained.[2] Almost all have instrumental introductions containing sometimes the theme or the suggestion of a theme of the song. Besides the introduction, there are several measures of purely instrumental parts unaccompanied by the words of the song. These usually occur at the end of the song, repeating the theme given in the introduction. There are endless varieties of exclamation, some of which are quite attractive though entirely meaningless, while others have distinct words with "catchy" meanings. All these features I designate as *ornamentation* of the songs, but strictly speaking they are not ornamentation of the songs, because they are indispensable and inherent parts of the songs. Throughout the entire work the word "ornamentation" is used in this sense.

1. *Form with two themes contrasted.* The songs of either two or four phrases are sometimes constructed in such a way that they break up into two distinct sections, where one is in contrast to the other.

2. *Form with three sections.* This group includes three elements or phrases irrespective of ornamentations, which could not be reduced to any simpler form, and corresponds to the ternary form of Occidental songs.

3. *Form with four sections.* The four sections separate into two, as in the case of the binary form of the Occidental songs.

[2] The Japanese songs used in this study are largely from the collection compiled by the Japanese Music Society of Tokio; a few are from other incidental publications. In the selection, Misses Heki Koike and Aiko Kawashima have furnished very valuable assistance.

The songs in this group have considerable ornamentation, yet a few simple ones conform exactly to some types of the Occidental songs.

4. *Form with elaborate construction.*—The songs in this group differ essentially from the others, in that they are of elaborate construction. Each has a principal and a subordinate theme; and these occur in varied forms as refrains.

In the following tabulation of the Japanese songs, the first column indicates the metre of the songs; the second column, the structure; the third column, any remarks on the songs; and the last, the name.

THE JAPANESE SONGS

Form with Two Themes Contrasted

Metre	Structure	Remarks	Name of the song
2/4	:I A I A: (I B— C′ C″ D) 3 4 3 4 3 4 2 2 3	Contrast of A and B	Izumo Bushi
2/4	I A B *meaningless exclamations* 4 4 4 7	Contrast of A and B	Ryusei Bushi
2/4	:A B A B *ex.*: 4 3 4 3	Contrast of A and B	Dagano Bushi
2/4	(A B) (C D) 9 8	Contrast of A B and C D	Okayama Bushi

Form with Three Sections

Metre	Structure	Remarks	Name of the song
4/4	*m m′* :i A B C : 3 3 4 3	*m* = refrain	Nanin Meisha
2/4	(i A B C) (i A B C) 2 3 3 3 2 3 3 3	Exclamation appears three times as motive	Kiso Bushi
2/4	*i′* i A B C 3 5 5 4	"i" is made up of three identical bars. C = *ex.*	Fukuchi Yama
2/4	I :A B: 4 8 4	I and B are of the same form	Oitoko Sōda

Form with Four Sections

Metre	Structure	Remarks	Name of the song
4/4	i A B B′ C 2 3 4 7 4		Kigari Kuzushi
2/4	(A B C D) :(A B C D): 2 2 2 2	Occidental in style but probably not by imitation	Inshu Inaba
2/4	A A′ B C 4 4 4 4	Occidental in style but probably not by imitation	Nogeno Yama

Metre	Structure	Remarks	Name of the song
$\frac{2}{4}$	I A — — — B — C D I 4 8 6 6 5 *ex.*	I and A almost alike: principal theme	Ume Wa Saitaka
$\frac{2}{4}$	A B C D 6 2 4 3	B is echo of A D is echo of C	Hitotsutoya
$\frac{2}{4}$	i A B C D — 3 4 4 4 5		Yoneyama Jinku
$\frac{4}{4}$	i A B — C — D — — 3 5 5 3 3		Enkaina
$\frac{2}{4}$	*m m m′ m* :I A B C D — — — — —: 3 3 2 2 2	*m* = refrain	Niagari Jinku
$\frac{4}{4}$	*m n mn mn* I A B C — — — etc. (13 bars) 2 2 3½ 3½	*n* = principal theme *m* = subordinate theme	Kinrai Bushi
$\frac{2}{4}$	*ex.* . . . . A B — C D (E F G — H) 3 4 1 2½ 1 1 1 4	"*ex.*" are intelligible words, such as stove, stick, pipe, etc.	Toka Ebisu
$\frac{2}{4}$	i A B (*ex.*) C D (*ex.*) (*ex.*) 3 3½ 4 2 1½ 3½ 1 1	"*ex.*" are meaningless	Oedo Nihon Bashi
$\frac{4}{4}$	I A B C D 10 11 6 10 9	"Long Song," contracted to folksong style Theme in I	Echigo Jishi

Form with Elaborate Construction

Metre	Structure	Remarks	Name of the song
$\frac{2}{4}$	i A B (*ex.*) A C — — (*ex.*) (*ex.*) 4 4 4 1½	A = principal theme B and C = subordinate themes	Fuitosa
$\frac{2}{4}$	*m m m* :i A B C — — — D E F — — —: 4 3½ 6½ 6 4 4 3	*m* = principal theme	Ariake Bushi
$\frac{2}{4}$	*m m* A B C D E 3½ 3 5½ 4 4	B = principal theme *m* = subordinate theme	Suika Busuika
$\frac{2}{4}$	*m m m m* A B C C′ B — — — — — — 6 4 2 2 4	*m* = refrain C = theme	Toyama Bushi
$\frac{4}{4}$	I (A A) B C (D D) — E C 1 1 2 1 1 1 2 1	I and A = theme	Osaka Bon Odori
$\frac{4}{4}$	*n m l m′ l n* A B C D E F — — — 2 4 2 4 2 4	*n* = principal theme *m* + *l* = subordinate theme.	Oki no Taisen
$\frac{2}{4}$	*m m m m* I A B C D D′ B′ C′ 2 4 4 2 2 2 3½ 3½	*m* = principal theme	Tango no Miyazu
$\frac{2}{4}$	A B C D E F 4 4 4 4 4 4	Equal number of measures in each phrase. The climax in C.	Kiri no Hoo

COMPARISONS

Of the fifty Occidental songs, twenty-one were grouped in the binary, or two-section form, seven in the ternary, or three-section form, and the rest in the combination form, and in the modified forms of the binary and ternary. What are the characteristics of each of these groups?

The songs in the binary group are constructed usually by the combination of two periods, or four phrases where one or more of them is repeated. In the type (A B) (A C), the period (A B) is balanced by another period (A C), and the phrase A is balanced by the different phrase B, and similarly A by C. In another type, (A B) (B A), there are four sections, employing two different phrases. The balancing is effected principally by the two periods, each composed of two elements, A and B. In still another type, (A A) (A′ A″), the first period consists of two like phrases; and its second period, slightly different from the first, consists of two phrases, both of which are modifications of the introductory phrase A. A song of this type possesses but little contrast or balance of phrases.

The structures (A A′ B C) (D D′ E C) (The Campbells Are Comin'); (A A B A) (Love's Parting); (A A B B′) (C B) (Home, Sweet Home) are similar to the preceding ones, but their members are enlarged. The preceding illustrations are all of regular and symmetrical types. In an irregular type (A A) (B C) + C (Dalecarlian Maiden's Song), the first part (A A) (B C) is complete in itself, but the phrase C is echoed at the end. A song of this type destroys the mechanical scheme of the symmetrical types.

In the ternary group, appear three kinds, A B B, A A B, and A B A, of the regular types, and a few others of irregular types, as $\overset{m}{A}\ \overset{m}{A} + m$.

Considering the different forms, we notice that in all cases the combinations of the phrases are influenced by the principle of balance. There is some approach to symmetry in all the different patterns. Each phrase has an equal number of measures through

out. One stands as important as the rest. If one is altered in any way, the alteration will necessarily affect the order, or the character of the song.

Examine the following structures (A A B A) (A A′ A B) :C D:, and (A B A) :C D:. The second part, which is an addition to the structure, already complete in itself, is of an order that does not overbalance the first part, and therefore does not destroy the aesthetic effect. There is a definite order or proportion observed throughout.

Of the Japanese songs examined, four were grouped under the form with two themes contrasted, four in the three-section group, twelve in the four-section group, and eight in the elaborate-construction group.

The songs of the form in which two themes are contrasted consist of either two or four phrases, so they might be classed as a subdivision of the four-section group. What warranted placing them by themselves is that the phrases or groups of phrases show strong contrast or balance. The principle of balance may be present in the other groups, but owing to the uneven number of measures in each phrase, as shown in the tabulation, its detection is difficult.

The songs in the three-section and four-section groups, I called simple constructions, because they are simple in comparison with the remaining groups, that of elaborate constructions. A few of these are quite similar in construction to those of the Occidental songs, (A B C D) (A B C D), A A′ B C, and I A B,
2 2 2 2   2 2 2 2   4 4 4 4
where I = A. Consider the song Hitotsu-Toya, A B C D. It is
6 2 4 3
constructed on the four-section scheme. The phrase B is a distant echo of the first phrase A; D again is an echo of the phrase C. The composition is very simple and of a very pleasing nature. This song Hitotsu-Toya, the "Counting Song," is sung throughout Japan. It is usually the first tune that the young folks begin to hum at play.

Those in the elaborate-construction group are built upon an elaborate scheme, having principal and subordinate themes con-

stantly recurring but in varied forms; to this is added considerable ornamentation, such as exclamations, either of intelligible or of meaningless words, instrumental introductions, and closings. Take, for example, Fuitosa, i A B (*ex.*) A C ——— (*ex.*) (*ex.*).
4 4 4
This song has four phrases, where A is the principal one, B and C being subordinate, but the exclamation (*ex.*) is the important feature of the whole composition. The exclamation introduces the name of the song "Fuitosa." This occurs three times, and has an attractive nature. Take, for another example, Toyama
m m *m* *m*
Bushi, A B C C′ B ——————. The *m* is the principal feature here; it may be considered either as a theme or as a refrain. And, besides, the song has six measures as an instrumental closing, the last three of which, taken together, are *m*.
n m m l m l n
Or, to take another song, Oki no Taisen, A B C D E F ———.
2 4 2 4 2 4
This is rather complicated. The number of measures in the phrases alternates between two and four. The *n* being the principal theme opens and closes the song. Both *m* and *l* are its subordinates.

As already stated, the comparison here attempted lays special emphasis upon the formal element, the phrase. But in the course of the study other matters, although not treated thoroughly, came to my notice matters, namely, connected with the tonality and the metre of the songs, which will be briefly discussed.

Among the fifty Occidental songs examined. the following show the results as to the tonality:

1. Those built upon the tonic basis 45
   Those built upon a member of the tonic chord as basis 4
2. Those built upon a doubtful basis 1

In examining the Japanese songs I assumed that they have a system of scales, irrespective of its character whether it is diatonic, or pentatonic, which is still a matter under discussion.

1. Those that seem to have been built upon the tonic basis 1
   Those that seem to have been built upon a member of the
   tonic chord 7

2. Those built upon a doubtful basis 22

Of those examined, consequently, nearly all of the Occidental songs have the tonic as basis, and should be classed as such. The Japanese songs, on the other hand, should be classed, for the most part, in the other group.

The metre, however complicated, may be regarded as of two kinds, that in which the accent is upon every second beat, "2's," and that in which it falls upon every third beat, "3's."

The Occidental Songs

1. Those with metre in "2's" 23
2. Those with metre in "3's" 27

The Japanese Songs

1. Those with metre in "2's" 30
2. Those with metre in "3's" 0

I am of the opinion that the melody of the Occidental song has a much more soothing quality than the melody of the Japanese. It is perhaps possible to account for this difference. The Occidental songs belong to the home life of the people, and have the spirit of the home, quiet and restful. As stated in the introduction, the Japanese songs find their use outside the home. As such they have a spirit that is hilarious rather than quiet and restful.

The division of a melody into small sections which are larger than a single measure, seems an indispensable fact in the Occidental songs. Their soothing quality is due partially to an impression of flowing, produced by this repeating pattern in the composition. On the other hand, the rhythm in the Japanese song is without such a pattern flowing through the compositions; the pattern rather is within the limits of a single bar, and the repetition of this from bar to bar gives a peculiar, jerky effect.

The Occidental songs possess the characteristics of dual and triple balance, symmetry, proportion. The organic unity of the song is manifested by a symmetrical balancing of periods, preserving usually an equal number of measures in each phrase throughout the composition, and closing each phrase with some form of cadence.

On the other hand, the Japanese songs have a characteristic irregularity. Only a few, as we saw, are built on the principle of balance, and in these there is some symmetry and proportion, no doubt. But in others those properties are absent. We should expect this, as the words of Japanese songs are for the most part not in formal metre, even when they are poetic. But perhaps the principal characteristic of the Japanese songs is their ornamentation. More than two-thirds of those I have examined have instrumental introductions and conclusions which are unlike the mere "accompaniment" in the Occidental songs, but are an inherent part of the composition. Some of these ornamentations contain the theme of the song, and others just a suggestion of the theme. There may be several measures occurring as a purely instrumental part, unaccompanied by the words of the song. The attractive exclamations are frequent features. These are the characteristic "ornamentation."

What are the similarities or differences in the mental attitude of the two races as regards these folksongs? The Occidental mind is directed toward and influenced by the organization of the different parts. This organization is determined by the *formal laws of balance, symmetry and proportion.* Each variation in the latter produces a corresponding change in the organization, and this again has an effect upon the mental and bodily condition.

Eliminating other pleasure-giving factors, the organic unity reacts on the mind of the Occidental as a favorable stimulation. As favorable, the stimulation is pleasurable. In the Japanese songs the above characters are not altogether lacking; it is only a question of degree. It is evident that both groups of people enjoy contrast and variety. But the principal source of the appreciation in the Japanese mind is not found in the formal structure. It is in the *attractiveness of the intricate ornamentation.* The Japanese mind delights in the minute display of things. This is the main difference between the two types of mind; one appreciates the beauty of organic unity; and the other, the beauty of the more casual and yet indispensable ornaments of the

song. I think it is true, that there is no connection whatever historically between the Occidental and the Japanese folksongs, yet both have elements in common: rhythm, melody, and harmony to a slight degree. The idea of contrast and variety is analogous in both. This, as a source of gratification, has through the ages diversified the forms of art. There are several points of interest in the differences. The melody in the Occidental song has a flowing quality as contrasted to that of the Japanese song with its hilarious spirit. The Occidental song uses the two usual metres, with equal and with unequal accents; whereas the Japanese song employs metre of equal accents only.

Transmitted December 18, 1915.

UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
PSYCHOLOGY
Vol. 2, No. 6, pp. 291-430 July 11, 1916

INDIVIDUAL AND SEX DIFFERENCES IN SUGGESTIBILITY

BY
WARNER BROWN

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

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UNIVERSITY OF CALIFORNIA PUBLICATIONS
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PSYCHOLOGY

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CONTENTS

I

INTRODUCTION

What is the actual basis of the assertion that some individuals are more readily influenced by suggestion than others? Is it true that some persons possess a trait which may be called "suggestibility", while others possess a certain positiveness of character which enables them to resist suggestions? And, in particular, is it true that men are less suggestible than women? With these questions in mind, experiments were carried on from August, 1912, till May, 1914, in the Psychological Laboratory of the University of California. These experiments were all very simple. The suggestions were given in the form of printed directions concerning what seemed to be perfectly commonplace laboratory exercises. The persons who received the suggestions were all students in elementary courses in psychology, and they were asked to do things which they thought they understood, and about which they had no misgivings. Careful and systematic inquiry made it certain that none of them suspected that the experiments had anything to do with suggestion, or that there

was anything misleading about the "directions" in which the suggestions were concealed.

The persons who conducted the experiments exercised little or no personal influence over those who took part in them. They merely handed the written directions to the subject and proceeded with the mechanical operations required by the experiment. Thus the suggestions were received by the subject while in a perfectly natural, active frame of mind, in complete ignorance of the fact that any suggestions were being made, and in the absence of the personal influence which is so conspicuous in hypnotic suggestion.

The experiments themselves were numerous, and not all of the subjects participated in all of them. Fifty-four women and twenty-nine men took part in all of the fifteen experiments of the first two groups; others took part in several of these experiments, but did not complete all. The experiments of these groups purported to discover the ability of the person, particularly the delicacy of his senses, his powers of sensory perception and discrimination, and his memory and imagination. The third group contained experiments which purported to measure two illusions of sense perception, to test the accuracy of estimate of distance and weight, and to obtain an expression of choice in matters involving a very simple esthetic preference. In this third group there were forty-one women and forty-three men. Each separate experiment involves its own peculiar difficulties and has its own points of special interest. In the following pages the experiments will be taken up one by one and the results given in turn. Special attention will be paid to sex differences wherever they appear. At the same time an effort will be made to show, whenever possible, to what extent "suggestibility" in the particular experiment is correlated with "suggestibility" in other experiments. This will inevitably involve a certain amount of forward reference. Those readers who have not sufficient interest to peruse the matter in the accounts of the separate experiments will find a summary of the more general results at the close of each chapter and in the final

chapters. In order to facilitate reference, the titles of the twenty-six experiments are given below in the order in which they were originally performed. For the systematic order of their presentation the reader may turn back to the table of contents. The first group were performed in the fall of 1912 and again in the fall of 1913. The second group were performed in the spring and again in the fall of 1913. The third group were performed in the spring of 1914.

LIST OF THE EXPERIMENTS IN THE ORDER IN WHICH THEY WERE ORIGINALLY PERFORMED

*First Group**

Page	Chapter	
298	II.	Least perceptible odors.
314	II.	Least perceptible electric shock.
308	II.	Least perceptible heat.
322	III.	Least perceptible change of brightness
326	III.	Least perceptible change of pitch.
354	V.	Memory for size (squares).

Second Group

Page	Chapter	
414	X.	Preference for a single color.
361	V.	Ink blot test of imagination.
349	V.	Recognition of form (checkerboard).
359	V.	Memory for pictures.
344	IV.	Progressive lines.
351	V.	Recognition of position (letters).
340	IV.	Progressive weights.
304	II.	Least perceptible touch.
333	III.	Least perceptible motion.
330	III.	Least perceptible change of size.

Third Group

Page	Chapter	
371	VII.	Size weight illusion.
377	VII.	Müller Lyer illusion.
416	X.	Preference between two tones.
402	IX.	Preferred triangle.
398	IX.	Preferred rectangle.
386	VIII.	Estimation of distance.
391	VIII.	Estimation of weight.
410	IX.	Preferred division of a line.
417	X.	Preferred color combination.
406	IX.	Preferred proportions of a cross.

* They were performed in these three groups, but in order to simplify the presentation they have been rearranged in the order in which they are given in the table of contents, as indicated by the Roman numerals at the left.

In each experiment an attempt was made to obtain an index of suggestibility or, in other words, a number which would represent the relative suggestibility of each individual in that particular experiment. This attempt was successful in eleven of the fifteen experiments of the first two groups and in seven of the ten in the last group. In these cases the individuals were arranged in rank according to the degrees of their suggestibility, the one who yielded most readily being first and the most resistant last. When such rankings had been obtained for different experiments the correlation was calculated between the rankings in the different experiments by the formula

$$r = 1 - \frac{6 \Sigma D^2}{n(n^2 - 1)}$$

If the ranking was the same in the two experiments, i.e., if number one in one experiment was number one in the other, number two in one was number two in the other, and so on, then the coefficient of correlation would be 1.00; if there was no correspondence whatever it would be 0; and if the rank in one experiment was exactly the reverse of the rank in the other it would be —1.00.

In calculating the correlations the sexes have been kept separate. Furthermore, correlations are usually given separately for each of the persons who conducted the experiments, for it is evident that if one experimenter managed to obtain higher indices of suggestibility for his subjects than those obtained by other experimenters this fact would give rise to a coefficient of correlation which would be misleading. It would be a correlation depending on the work of the experimenter and not upon the suggestibility of the subject. But the files for the separate experimenters are in many cases too short to give reliable coefficients of correlation or reliable averages for sex differences. Moreover, there are numerous cases in which the experiments of group I were administered by one experimenter and those of group II (for the same subject) by another. General averages for all persons and correlations for the entire first division (groups I and II), without regard to experimenter, will there-

fore be found together with the other figures. In the last ; of experiments separate figures for the different experim(are not feasible, for reasons which will be produced in due

Careful readers will note that the total number of sul entered for correlations does not tally, in some instances, the total number taking part in the experiment, and tha number of subjects ascribed to an experimenter is not al the same. These discrepancies arise from the fact that (lations must be calculated on the basis of the experiment the fewest subjects. On that account data had to be rej from the correlations which were perfectly good for other poses. Moreover, the calculations for different purposes made at different times, and records were at times incl which could not be used in subsequent calculations. Fur more, there were a few cases in which the experimenters ı mistakes, and in some of them the record was acceptable : one point of view but not from another (for example, givin; time but failing to note the direction of a change of pitch). some cases all the experiments made by one person have excluded from the general average when there was some que: about the experimenter's procedure. If all of the discrepa had been rectified, a considerable amount of valuable data ı have been rejected and an enormous amount of labor would] been involved in recalculations.

The experiments were performed by the following stud(all of whom were doing advanced or graduate work in laboratory:

Miss G. Atkinson (A), all three groups of experiments.
Miss T. S. Cockcroft (C), first two groups.
Mr. L. W. Fike, last group.
Mr. A. I. Gates (G), first two groups.
Mr. W. S. Heller (He), first two groups.
Miss M. T. Hodgen (Ho), first group.
Mr. S. Ito (I), first two groups.
Miss L. Jackson (J), first group.
Miss K. M. McKee (M), first group.
Mr. F. C. Nass, last group.
Mr. Y. Sugisaki (S), first two groups.
Miss R. E. Wolf, last group.

Credit is due these students, not only for the careful manner in which they performed the experiments but also for many suggestions in planning the work, and for very helpful preliminary surveys of the data.

The plan of a group of experiments to test the possible differences in suggestibility between the sexes came from the director of the laboratory, Professor Stratton. He had a large share also in the devising of the details of the experiments and in the supervision of the experimenters. Moreover, the writer is under great obligation to him for advice and encouragement in the preparation of this report. No attempt will be made to discuss systematically in this report the original sources of the various experiments which have been made use of. We are under obligation to Scott,[1] Whipple,[2] and Chojecki[3] for calling attention to the problem of individual differences in suggestibility. From numerous experimenters, particularly Seashore,[4] several experimental devices and methods have been adopted. Above all we are indebted to Binet,[5] from whom we have borrowed freely ideas and methods, both for particular experiments and for the work in general. Some of the experiments have been taken over bodily from the work of previous investigators. A number have been modified to meet our special needs. Several were devised for the occasion, but these were not generally the inventions of one person, but resulted from co-operative planning in the laboratory.

[1] Scott, W. D., "Personal differences in suggestibility," *Psychol. Rev.*, vol. 17, 1910, p. 147.

[2] Whipple, *Manual of Mental and Physical Tests*, p. 444, edition of 1910.

[3] Chojecki, A., "Contribution à l'étude de la suggestibilité," *Arch. de psychol.*, vol. 11, 1911, p. 182.

[4] Seashore, C. E., "Measurements of illusions and hallucinations," *Studies from the Yale Psychol. Lab.*, vol. 3, 1895, p. 1.

[5] Binet, A., *La suggestibilité*, Paris, 1900.

II

FOUR TESTS INVOLVING A "LEAST PERCEPTIBLE" (IMAGINED) SENSATION

1. Odors; 2. Touch; 3. Heat; 4. Shock

Four experiments are concerned with imaginary sensations. They were all so arranged as to lead the subject to believe that he would experience a weak sensation. The force of the suggestion was probably enhanced in many cases by the thought of competition with others. In fact, the appeal, through the spirit of competition, to the pride of the student plays a conspicuous part in nearly all of the experiments. It is understood, of course, that there was no actual competition; each student was tested separately.

1. Odors[6]

The following set of typewritten instructions and explanations was handed to the subject:

DELICACY OF THE SENSE OF SMELL

It is the object of this experiment to measure the delicacy of your sense of smell.

The experimenter will let you smell comparatively strong samples of each of three odors—peppermint, wintergreen, and ethyl alcohol.

You will then be given ten bottles in succession. You are to smell of each of these carefully and report in each case whether you smell one of the odors you have just sampled, some other odor, or no odor at all.

The ten bottles referred to were conspicuously numbered from one to ten, in order. They contained distilled water. Of the three actual odors used, one was pure alcohol and the others were 15 per cent colorless solutions of essence of peppermint and essence of wintergreen in water.

A record was kept for each person showing what he reported for each of the ten bottles of water. The average results are

[6] A similar experiment is described by Seashore, *Yale Studies*, vol. 3, 1895, p. 58; by Small, M. H., *Ped. Sem.*, vol. 4, 1896, p. 177, and by Slosson, S. S., *Psychol. Rev.*, vol. 6, 1899, p. 407.

given below for women, for men, and for both, in terms of the number of answers out of the possible ten.

Answer made by subject	123 women	62 men	185 persons
"Nothing"	5.19	6.32	5.57
"Alcohol"	1.39	1.32	1.37
"Wintergreen"	1.43	1.08	1.31
"Peppermint"	1.47	0.98	1.31
Other	0.50	0.29	0.43
Total sug.	*4.80*	*3.68*	*4.43*

It is evident from this table that the differences between the odors used for the introduction of the suggestion do not affect the results to any considerable extent.

The index of suggestibility was obtained by taking the sum of the reports for alcohol, wintergreen, peppermint, or any other specific odor. The proportion of "other" odors was small.

The table above shows that the average index of suggestibility for women is considerably higher than that for men, indicating that in this experiment the women are much more suggestible. The following figures show that the greater suggestibility of the women which appears in the average figures is confirmed by the separate findings of the different experimenters.

Experimenter	Number women	Index sug.	Number men	Index sug.
A	13	4.54	6	4.00
C	12	4.25	7	1.30
G	16	7.06	7	5.59
He	11	4.00	9	3.22
Ho	13	4.08	1	6.00
I	13	5.85	5	2.20
J	9	5.22	6	3.17
M	26	3.88	8	3.75
S	10	4.70	13	4.69
All	123	4.80	62	3.68

The difference between the sexes in this experiment stands out in spite of the fact that the various experimenters had very unequal success with the experiment. Seven of the nine experimenters find the women more suggestible than the men.

Data were taken from all comers, even persons who had, or claimed to have, "colds" which interfered with their sense of smell. The number of "colds" which seemed to develop suddenly was somewhat disconcerting to the experimenters. It will be observed, however, that in spite of the "colds" the average person is able, under mild suggestion, to smell an odor in four or more out of ten bottles of odorless water.

The distribution of the individuals according to the frequency with which different degrees of suggestibility occurred is given in the following table and in the graph (fig. 1). The graph does not follow the table exactly, but presents the same data in a more condensed and more readily comprehensible form. The graph, and all the similar ones which are to follow, are so constructed that one centimeter in altitude represents 4 per cent of the subjects. The difference between the sexes is again apparent here. Not only do the women give a smaller proportion who fail to respond to any of the suggestions, but a larger proportion of the women yield to the suggestion for each separate bottle or for a large number of bottles. Half of the women respond to the suggestion five or more times among the ten bottles, while only a third of the men do so.

There were a number of persons who refused to admit that there was any odor about any of the bottles of water. Men are about three times as apt to make such a complete resistance to the suggestion as women. Only 7 of the 123 women were thus completely immune to the suggestion, while 11 of the 62 men were.

ODORS

Frequency of Different Degrees of Suggestibility

The figures are the percentile proportion of the subjects who thought they perceived an odor in 0 bottle, 1 bottle, 2 bottles, etc., up to the whole number of 10 bottles.

Bottles	Women	Men	Bottles	Women	Men
0	5.0%	16.4%	6	16.5%	11.5%
1	11.6	8.2	7	10.7	4.9
2	6.6	14.8	8	7.4	6.6
3	9.9	11.5	9	3.3	3.3
4	12.4	14.8	10	7.4	3.3
5	9.1	4.9			

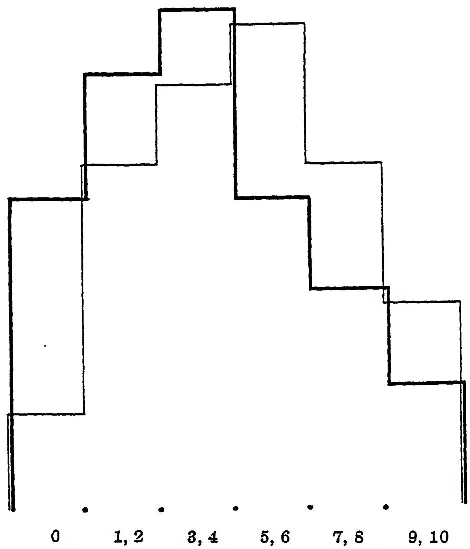


Fig. 1—Odors. Light line, women; dark line, men.

It was found that the effectiveness of the suggestion increased regularly from bottle to bottle up to the eighth bottle. More persons yielded to the suggestion on the eighth bottle than on any other one. Very few yielded on the first or second, and very few yielded on the very last.

The correlation between suggestibility in this experiment and suggestibility in nine other tests is shown in the following table. The tests with *Touch, Heat,* and *Shock* rest upon a suggestion in terms of "least perceptible" sensations; those in *Change of Brightness,* of *Pitch,* of *Size,* and of *Motion* rest upon a suggestion of least perceptible change; those with *Progressive Weights* and *Lines* rest upon a suggestion of continuity.

The entries opposite "All" in this table do not refer to the total number of subjects of all the experimenters. As has been explained, some of the subjects who took part in one or another experiment did not take part in others, or perhaps their work was rejected in some experiments but not in others. But there

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE EXPERIMENT WITH ODORS AND SUGGESTIBILITY IN NINE OTHER TESTS

Women

Experimenter	Number cases	Touch	Heat	Shock	Brightness	Pitch	Size	Motion	Lines	Weights
A	14	......	.35	.07	—.05	—.31	......	......	......	......
C	12	......	.73	.27	—.11	—.12	......	......	......	......
G	16	......	.09	.38	—.87	.15	......	......	......	......
He	11	......	—.05	.05	.20	.06	......	......	......	......
Ho	13	......	—.35	—.41	—.14	.00	......	......	......	......
I	13	......	.00	—	.33	—.30	......	......	......	......
J	9	......	—.15	—.03	—.35	.35	......	......	......	......
M	24	......	.23	—.20	.33	—.11	......	......	......	......
S	10	......	.18	—.60	.00	—.32	......	......	......	......
All	54	—.01	.11	—	.05	—.10	.08	—.28	.28	.18

Men

Experimenter	Number cases	Touch	Heat	Shock	Brightness	Pitch	Size	Motion	Lines	Weights
A	6	......	.54	.14	.55	.25	......	......	......	......
C	7	......	.03	.45	—.32	.57	......	......	......	......
G	7	......	.88	.43	.11	.40	......	......	......	......
He	9	......	.18	—.37	—.28	.19	......	......	......	......
Ho	1	......	—	—	—	—	......	......	......	......
I	5	......	—.30	—	.50	.75	......	......	......	......
J	6	......	.89	.49	.57	—.40	......	......	......	......
M	8	......	.63	.11	—.22	.18	......	......	......	......
S	13	......	.86	.32	.37	—.05	......	......	......	......
All	29	.23	.26	—	.40	.16	.39	.14	.24	.16

were 54 women and 29 men who completed all the nine experiments of this division. Correlations have been made out for these 54 women as a single group, regardless of who performed the experiment, or whether it was performed at the same sitting or at a different sitting, and so for the 29 men. These are the correlations which are entered opposite "All" in this and subsequent tables. The correlations which are filled out for the separate experimenters are for pairs of tests which were performed at a single sitting and by that experimenter. The columns which are not filled out for the separate experimenters

are for pairs of tests which were performed at a different sitting and, usually, by different experimenters. Blanks occur where the work of some experimenter must be rejected. The column for *Shock* is not filled out opposite "All" because the methods of different experimenters were not sufficiently uniform to warrant the computation of a correlation.

There is some evidence of positive correlation. When the larger groups of students are considered who, under the heading "All", were experimented upon by various experimenters, it appears that five of the eight tests give positive correlations for women and that the whole eight give positive correlations for men. When the smaller groups are considered, all of the members of which were experimented upon by a single person, the women show fifteen positive and seventeen negative correlations, while the men in these small groups show twenty-four positive and seven negative correlations. While positive correlations seem to predominate, it will be observed that the figures are not high. The difference between the correlation figure for the men and that for the women is characteristic of most of the tests; for some reason the men's correlations are regularly higher.

The correlations do not seem to be any higher with tests involving the same general type of suggestion (*Touch*, *Heat*, *Shock*) than with tests of an entirely different nature. Nor does the amount of correlation seem to depend to any great extent upon the presence of the same operator for the two tests. The figures at the foot of the open columns, which represent pairs of tests in which the two tests were usually administered by different experimenters and at different times, seem to be about the same as those at the foot of the filled columns, in which the same experimenter carried on both tests at the same sitting.

The essential findings concerning the *Odors* experiment are:

1. Women are considerably more suggestible than men.

2. A low but (at least for men) positive correlation is found between this test and other tests.

3. The correlation is much stronger for men than for women.

2. TOUCH[7]

The typewritten directions which were handed to the subject were as follows:

LEAST PERCEPTIBLE WEIGHT

You will see a set of small cork weights, some of which are so light that they can not be felt at all. It is the purpose of this experiment to find the lightest of this set of weights which you can feel on the tip of the middle finger. When the experimenter says "ready" you are to see whether you can feel the weight or not and report to the experimenter immediately.

The cork weights were cylindrical in shape and two millimeters in diameter. They were suspended by a silk thread. The subject was shown that one of these weights aroused no sensation when placed upon the finger-tip, while another weight, which was heavier, was clearly perceptible. The subject then thrust his hand through a slit in a curtain and let it lie upon the table. The perceptible weight was applied four times with a signal "ready" each time. Then the signal "ready" was given ten times with the same intervals between, but no stimulus was applied to the finger. Suggestibility is measured by the number of positive answers for the ten trials. In the following table the number of subjects and the number of positive answers for the ten trials of each subject are given for each experimenter separately.

Experimenter	Number women	Index sug.	Number women	Index sug.
A	19	1.53	10	1.40
C	9	1.11	5	1.20
G	19	3.05	6	3.83
He	10	2.10	18	0.89
I	12	2.08	8	1.75
S	10	2.80	11	1.09
All	69	2.16	58	1.46

It will be seen that the average figures show a considerably higher index of suggestibility for the women than for the men.

[7] A similar experiment is described by Seashore, *Yale Studies*, vol. 3, 1895, p. 56. Small, *Ped. Sem.*, vol. 4, 1896, p. 184, employed a somewhat different plan.

This average is, however, probably too high, for there are two experimenters who find men more suggestible, and if we take out the data obtained by experimenter He., who obtained in this experiment extreme differences between the sexes, the average indices become 2.17 and 1.73 for women and men respectively. This figure is probably a reliable measure of the greater suggestibility of the women in this experiment.

Here, as with the *Odors,* there are relatively more men who refuse to admit any positive touches in the series of ten. There were 22 men out of 58 who thus rejected the suggestion *in toto,*

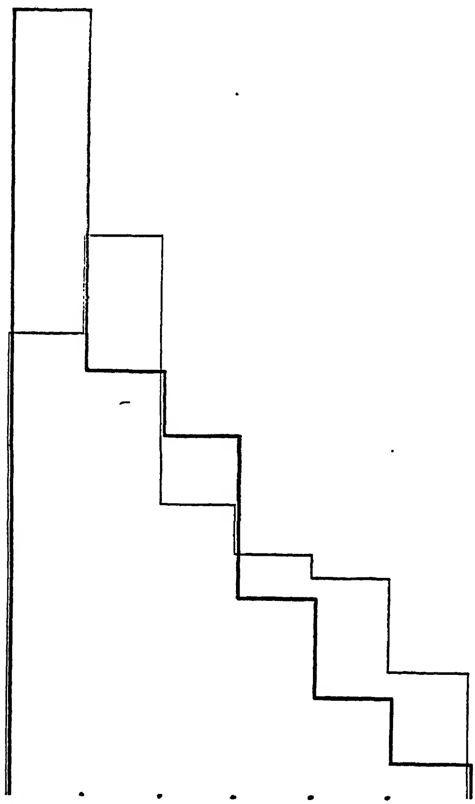


Fig. 2—Touch. Light line, women; dark line, men.

and there were only 16 women among 79 who did so. But ten of these men were under the direction of experimenter He., and if we exclude his data we find 12 men among 40 and 15 women among 69, that is to say, one man among 3.3 refuses to yield to the suggestion and one woman among 4.6.

The graphic representation of the relative frequencies of the different degrees of suggestibility (fig. 2) shows the same general type of distribution for both sexes. But the distribution is much more scattered for women than for men. Not only do fewer women fail on all ten trials, but more women respond positively to a large proportion of the ten trials.

TOUCH

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures are the percentile proportion of the subjects who thought they perceived a touch in no case, in 1 case, in 2 cases, etc., up to the whole number of 10 trials.

rials	Women	Men	Trials	Women	Men
0	24.4%	41.4%	5	2.6%	1.7%
1	29.5	22.4	6	1.3	0
2	15.4	19.0	9	1.3	0
3	12.8	10.3	10	1.3	0
4	11.5	5.2			

Positive answers were given three or more times by a third of the women, but only one in six of the men gave as many as three positive answers.

A comparison of the graphs for *Touch* with those for *Odors* (p. 301) shows at once that the suggestion in *Touch* is not as effective as the suggestion in *Odors,* in spite of the very great similarity of method between the two experiments. While the average person imagines that he detects an odor in 4.4 of the 10 bottles of water, he admits feeling a touch only 2.6 times in 10 trials. Apparently the suggestion with odors is about 1.7 times as effective as the suggestion with slight pressure on the finger. The suggestion of touch was entirely rejected by almost three times as many persons, in proportion to the whole number taking part in the test, as rejected the suggestion of odor. Com-

paratively few individuals responded as many as five times to touch, although half of the women and a third of the men responded five or more times to odors.

The correlation between the suggestibility of the various persons in the touch experiment and their suggestibility in other tests is given in the following table. A statement of the general nature of these other tests has already been given (p. 301). As was explained before, the filled columns of the tables are for tests which were given by the same experimenter and at the same sitting with the one for which the correlations are made out (now *Touch*) and the open columns are for tests which were made at a different sitting and, generally, by different experimenters.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE EXPERIMENT WITH TOUCH AND SUGGESTIBILITY IN NINE OTHER TESTS

Women

Experimenter	Number cases	Odors	Heat	Brightness	Pitch	Size	Motion	Lines	Weights
A	19	......	......	......	......	.01	.24	—.06	—.24
G	19	......	......	......	......	—.10	.22	.44	.05
He	9	......	......	......	......	.19	.45	—.06	.68
I	12	......	......	......	......	.12	—.33	.42	—.08
S	11	......	......	......	......	.07	.06	.47	.04
All	54	—.01	.35	.15	.27	.04	.07	.14	—.13

Men

Experimenter	Number cases	Odors	Heat	Brightness	Pitch	Size	Motion	Lines	Weights
A	10	......	......	......	......	.16	—.05	.06	—.20
G	6	......	......	......	......	.20	.14	.03	—.46
He	18	......	......	......	......	.33	.51	.33	.08
I	7	......	......	......	......	.34	.57	.08	.24
S	11	......	......	......	......	.35	—.40	.18	.08
All	29	.23	.19	.42	.15	.30	.19	.17	.11

Of the twenty correlations for the separate experimenters, fourteen of the women's and sixteen of the men's are positive. In the correlations for the larger groups where the data from several experimenters are combined only one case (*Progressive*

Weights, for women) is clearly negative; one case (*Odors,* for women) is practically zero. On the whole, it seems proper to say that there is a distinct positive correlation between the results of this test and those of other tests, but that the actual amount of the correlation is not great. No particular test seems to be more closely related than another to this test, at least not conspicuously so.

The general results of this experiment may be stated as follows:

1. Women generally yield more readily than men to a suggestion of light touch.

2. Persons who yield readily to this form of suggestion will be apt to yield to other forms of suggestion.

3. The correlation between this test and others is higher for men than for women.

3. Heat[8]

The instructions were as follows:

LEAST PERCEPTIBLE WARMTH

It is the purpose of this experiment to determine the smallest amount of heat which you can feel with your finger.

Wait until the box has been heated by the electric current for one minute. Then let the index finger follow the indicator slowly into the hole until you feel the least perceptible warmth from the heated coil within.

If you do not feel the warmth the first time allow the current to heat the box for another minute and then try again. If you still fail to feel the warmth it means that your sense of temperature is not sufficiently delicate and the experiment must be given up.

The box contained a small hole into which the finger could be inserted. Within this hole the finger came in contact with a piece of velvet attached to a flat disc. The disc was attached to the short arm of a lever of which the other arm extended out-

8 The experiments of this type by Seashore, Small, Guidi, and Scott are discussed by Whipple in his *Manual of Mental and Physical Tests,* pp. 423–428 of the edition of 1910. The method here adopted is a variation of that of Guidi ("Recherches expérimentales sur la suggestibilité," *Arch. de psychol.,* vol. 8, 1908, p. 49). Guidi's method was also employed by Chojecki, *Arch. de psychol.,* vol. 11, 1911, p. 182.

side the box in the form of a pointing indicator which could be moved along a scale on the outside of the box. As the indicator moved along the scale the disc within the box moved farther in and permitted the finger to be inserted farther. The box was covered with dead black paper and was loaded with lead to make it heavy enough to justify the "coil within." There was an incandescent electric light on the top of the box. The wire from this light passed in and out of the box in a conspicuous manner, but produced no heat within the box.

At first we allowed the subject to insert his finger into the box as fast as he liked, pushing the indicator along by the pressure which he exerted against the disc. Under these conditions we recorded both the time and the extent to which the finger was inserted into the box. This involved the difficulty that some persons pushed the finger in very rapidly while others proceeded in a very gingerly fashion. Later the indicator was moved along the scale by the experimenter at a uniform rate, allowing the finger to enter only as fast as it moved. In either case suggestibility was measured by the time (or distance) of insertion before the heat was reported. As both methods of scoring were used with a considerable number of persons it is possible to make a comparison of the rankings obtained by time and by distance. The following table gives the correlation between the ranking according to *time* and according to *distance*.

HEAT EXPERIMENT—CORRELATION BETWEEN THE RANK ACCORDING TO DISTANCE ON THE SCALE AND ACCORDING TO TIME

Experimenter	Number cases, women	Cor.	Number cases, men	Cor.
G	16	.77	7	.46
He	11	.90	9	.88
M	26	.99	8	.90
J	9	.93	6	.86
Ho	11	.78	None	

As the correlations are quite high for all of the experimenters, it is evident that either method of scoring will give practically the same ranking that would be obtained by the other method.

It may be of interest to note that this statistical result is a direct contradiction of the casual observations of all of the experimenters. The experimenters all thought that if a subject pushed in rapidly his score would show a high reading on the scale and a short time. The result proves that this "observation" was an inference, and that in fact those who push in rapidly stop before they have got far in, so that their record shows a low reading of the scale as well as a short time. However, the method later adopted of controlling the movement so that the finger can go in only one degree of scale per second of time seems, on the whole, a preferable method so far as the score is concerned.

The following table gives the significant facts regarding sex differences in this experiment. It shows for each experimenter the number of subjects tested and the proportion of them who failed to respond to the suggestion on the first trial. It also shows the average time required for the response of those who did yield to the suggestion.

Experimenter	Number women	Per cent failures	Index sug.	Number men	Per cent failures	Index sug.
A	14	50.0	9.0	6	66.7	9.3
C	14	35.7	7.9	7	42.9	8.0
G	16	12.5	22.8	6	16.7	16.8
He	11	36.4	14.5	9	44.5	10.4
Ho	14	35.7	10.6	1	100.0	....
I	13	15.4	10.4	5	40.0	7.0
J	9	44.5	13.7	6	16.7	8.3
M	26	50.0	5.0	8	62.7	4.9
S	10	30.0	13.5	12	41.7	15.5
All	127	37.8	18.16	60	43.3	19.62

All the experimenters except one (*J*) report that more men than women refuse to yield to the suggestion, and in the average it appears that the men are slightly more resistant. On the other hand, five of the eight experimenters report that the men who do yield to the suggestion do so in a shorter time than the women. The fact that the average time for all the men who yield is slightly greater than the average time for all the women must not be taken too seriously. All of the experimenters who

obtained slower reactions for the women belonged to the group who worked with a fixed rate of movement. It is not improbable that this fixed rate delayed the response of the more impetuous men. At any rate, if we take only the persons who worked at their own speed, and were subject to a double score, we get the following average figures:

49 women, average time, 18.90 seconds, average scale 39.8.
18 men, average time, 15.78 seconds, average scale 32.2.

We ought also to take into consideration the data of the second trial, made one minute later with all those persons who failed to yield to the suggestion on the first trial. The second

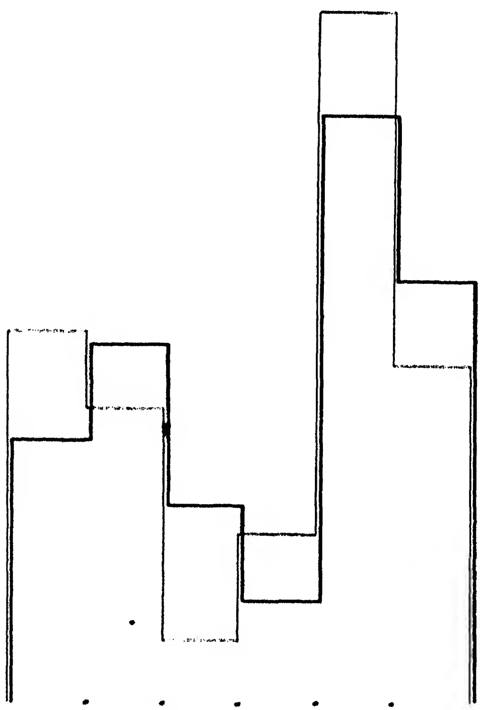


Fig. 3 Heat. Light line, women; dark line, men.

trial left only 14 per cent of the men still holding out against the suggestion, while of the women 19 per cent were still holding out. In other words, although there was a large number of men who resisted the first trial, two-thirds of them fell a prey to the second, while only half of the women who survived the first test yielded to the second.

An inspection of the graph (fig. 3) throws some light on this somewhat muddled set of data. This graph shows the distribution of the persons according to the lengths of time that they resisted the suggestion. It shows that more men resisted the first test, and that more women finally resisted both tests. In the first test a larger proportion of the women hold out for a period of thirty seconds or longer.

HEAT

Frequency of Different Degrees of Suggestibility

The figures are the percentile proportion of the subjects who confessed to feeling warmth after various intervals of time.

Time	Women	Men
Not at all	19.2	13.6
21–30 seconds, second trial	8.8	3.4
11–20 seconds, second trial	6.4	15.2
1–10 seconds, second trial	3.2	10.2
Over 30 seconds, first trial	8.8	5.1
21–30 seconds, first trial	12.8	18.6
11–20 seconds, first trial	23.2	11.9
1–10 seconds, first trial	17.6	22.0

In view of all of these facts it seems clear that men are more suggestible in this test, in spite of the fact that more men resist the first suggestion and that their gross average time of resistance is slightly greater. Fewer resist the cumulative effect of the two suggestions and a larger proportion of the men yield to the suggestion abruptly.

All of the data of this experiment are open to some criticism on the ground that there was not sufficient uniformity of method in conducting the tests.

The correlations of the heat test with the other tests will be found in the following table. The general arrangement is the

same as that observed in the case of *Odors* and *Touch*. In computing the rank for correlation the second test has been treated as if it were a direct continuation of the first, so that the shortest time recorded for the second trial takes the rank directly after the longest time for the first trial.

The correlation with *Touch* seems to be particularly high in spite of the fact that this was one of the experiments performed at a different time and by different experimenters. The correlation with *Odors* is also fairly high, as these correlations go. The results of the separate experimenters' figures indicate a relatively high positive correlation with *Heat* and *Shock*. As will be explained in the next section, the methods of adminis-

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE HEAT EXPERIMENT AND SUGGESTIBILITY IN NINE OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Shock	Brightness	Pitch	Size	Motion	Lines	Weights
A	14	....	.35	.34	.66	.13	......	......	......	......
C	12		.73	.45	.29	.41	......	......	......	......
G	16	....	.09	.09	.22	.28	......	......	......	......
He	11	....	.05	.42	.44	.23	......	......	......	......
Ho	14		.37	.32	.16	.45	......	......	......	......
I	13	....	.00		.47	.19	......	......	......	......
J	9		.15	.15	.31	.06	......	......	......	......
M	24	....	.23	.08	.09	.01	......	......	......	......
S	10	....	.18	.15	.13	.39	......	......	......	......
All	54	.35	.11		.07	.29	.04	—.24	.15	.05

Men

Experimenter	Number cases	Touch	Odors	Shock	Brightness	Pitch	Size	Motion	Lines	Weights
A	6	....	.54	.09	.26	.26	......	......	......	......
C	7	....	.03	.12	.65	.69	......	......	......	......
G	7	....	.88	.44	.06	.48	......	......	......	......
He	9	....	.18	.17	.19	.32	......	......	......	......
Ho	1	....	....	....	....	....	......	......	......	......
I	5	....	.30		.30	.70	......	......	......	......
J	6	....	.89	.60	.36	—.71	......	......	......	......
M	8	....	.63	.12	.16	.26	......	......	......	......
S	12	....	.86	.38	.00	.01	......	......	......	......
All	29	.19	.26	....	.04	.06	.26	.09	.04	—.16

tering the shock experiment varied so much from one experimenter to another that it was impossible to compute a correlation for the larger groups in which the work of several experimenters would have to be combined.

Out of eight sets for the larger groups, six are positive for women and seven for men. Among the correlations for the subjects of separate experimenters there are twenty positive to fourteen negative for women and twenty-four positive to six negative for men.

The conclusions from this experiment are:

1. More men than women resist the first suggestion of heat, but fewer resist the cumulative effect of two suggestions, and the men who do not resist yield to the suggestion sooner than the women who yield.

2. There are more positive than negative correlations between this test and other tests, and there is a definite correlation between this test and *Touch*, *Odors*, and *Shock*, all of which are tests of the same general type.

3. The correlations are much more distinctly positive for men than for women.

4. Electric Shock[9]

A Dubois-Raymond induction coil was arranged on the table in front of the subject, with an oscillating reed which interrupted the primary circuit twenty times per second. Wires leading from the secondary circuit were dropped into jars of water. The subject placed his index finger in one jar and the middle finger of the same hand in the other jar. A secret key enabled the experimenter to cut out the circuit from the secondary coil without stopping the noisy interrupter, which continued to sputter on the table before the eyes of the subject. The directions were as follows:

[9] A similar experiment was performed by Seashore, *Yale Studies*, vol. 3, 1895, p. 59.

ELECTRIC SHOCK

It is the purpose of this experiment to measure the weakest induced current which you can feel passing from one finger to the other.

You are to sit with the first and second fingers of your left hand dipped in the glasses of water which contain the electrodes. The experimenter will start the current through the primary coil and then pull the secondary coil slowly up until you feel the current distinctly. This is merely to acquaint you with the working of the apparatus.

The experimenter will then push the coil back and start it up again very slowly. You are to keep a sharp lookout for the first faint shock and as soon as you are sure that you feel it tell the experimenter to stop.

In case you do not feel the current soon enough, the experimenter may again return to the starting point. The experiment may be repeated two or three times at the discretion of the experimenter.

The subject watched the movement of the secondary coil as it was drawn up by a windlass. For the first trial the coil was drawn up with the current in action until the subject felt the shock distinctly. The second time (to measure the "least perceptible shock") the current was secretly cut out. In case of failure, another trial was made without current. In some of the work an actual shock was administered to persons who twice refused to feel the imaginary shock. This did not affect the data of this experiment, but may have influenced the suggestibility of the subject in later tests.

The index of suggestibility in this experiment can not be ascertained without knowing the point at which the current was actually felt when it was in action. The distance between this point and the point where the subject imagined he felt a "least perceptible" current, when there really was none, is taken as the measure of the suggestibility of the subject. Such a method is made necessary by the fact that different persons differ greatly in sensitivity to this form of electric stimulation. For that reason the absolute reading of the scale does not permit of any comparison between individuals with regard to suggestibility. Furthermore, we were not very successful in keeping the actual strength of the primary field constant, so that readings at different times were not precisely comparable. But this method of scoring involves a serious difficulty, for it proved to be im-

possible to get the different experimenters to adopt a uniform idea of what constitutes an actual shock which can be "clearly felt." Some waited to see their subject squirm a little before stopping the advance of the coil. Others stopped the coil on the very first indication that any current was being felt. There seems good reason to believe that the coil was sometimes stopped and a record entered for "actual shock" when no actual, but only a faintly imagined, shock had been experienced by the subject. On account of this difficulty with the method of scoring no attempt has been made to compute correlations involving the work of different experimenters.

It may be noted in passing that the average point at which women are reported as feeling the actual current is considerably lower than the corresponding point for men. The difference is nearly 30 mm. on the scale of the instrument, a distance which represents, for any particular individual, a change from a just perceptible to a distinctly unpleasant sensation. This difference may be, as it purports to be, a real difference in the sensitivity of the sexes, or it may mean that the report of an actual shock was entered, in the case of the women, more times when there was no actual shock. If the latter hypothesis is correct it means that the women are more suggestible before any shock has been administered.

The following table gives the results, such as they are, obtained by the different experimenters. It will be seen that the men appear, on the average, to be better able to resist the sug-

Experimenter	Number women	Per cent failures	Index sug.	Number men	Per cent failures	Index sug.
A	14	35.7	47.8	6	16.7	25.0
C	12	50.0	78.2	7	42.8	42.5
G	16	0.0	15.8	7	14.3	9.0
He	9	22.2	25.7	5	60.0	17.5
Ho	14	7.1	95.6	1	0.0	140.0
J	8	37.5	55.2	6	33.3	131.2
M	26	3.8	74.2	8	12.5	57.1
S	8	50.0	34.8	11	18.2	18.9
All	107	20.6	57.2	51	25.5	42.6

gestion and that those of them who yield wait longer (i.e., wait for the coil to approach more nearly to its former position) before they yield. The index of suggestibility is the distance in millimeters on the scale of the instrument between the "actual" and the imaginary shock. But while the general average shows the men more resistant, that is, less apt to report the current, yet four of the eight experimenters found the contrary to be the case, namely, that a larger proportion of the women refused to give in to the suggestion.

In these scores the results of only the first trial are recorded. The second trial will be used in computing correlations, but reference to it in connection with the per cent of failures does not clarify matters. There were only a few scattering cases in

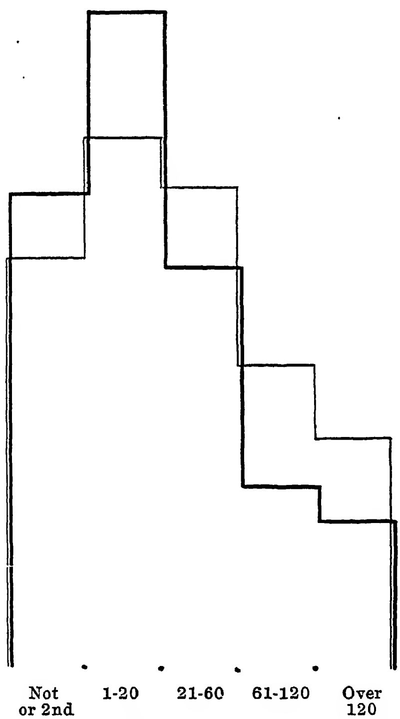


Fig. 4—Shock. Light line, women; dark line, men.

which a failure to respond to the suggestion on the first trial was followed by submission to the suggestion in the second trial.

The graphic representation (fig. 4) of the relative frequencies of different degrees of suggestibility in men and women confirms the impression that men are less suggestible in this test than women. Not only is the proportion of total resistance greater among men than among women, but a larger proportion of men wait until the coil has almost (20 mm. or less) reached the point at which they first felt the shock before yielding to the suggestion. There are fewer cases of extreme suggestibility among the men.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures are the percentile proportion of the subjects who confessed to feeling the shock at various distances from the point where they first felt the actual shock.

Distance	Women	Men
Not at all, or only on second trial	21.5	25.0
1–20 mm. before point of actual shock	28.0	34.6
21–40 mm. before point of actual shock	16.8	13.5
41–60 mm. before point of actual shock	6.5	7.7
61–80 mm. before point of actual shock	7.5	5.8
81–120 mm. before point of actual shock	8.4	3.8
121–160 mm. before point of actual shock	5.6	5.8
161 mm. or more before point of shock	6.5	1.9

The following table gives the correlation between ranking in this experiment and ranking in four other tests, as obtained by the several experimenters. As has been explained already, it

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE SHOCK EXPERIMENT AND SUGGESTIBILITY IN FOUR OTHER TESTS

Experimenter	Number women	Odors	Heat	Brightness	Pitch	Number men	Odors	Heat	Brightness	Pitch
A	14	.07	.34	.10	—.29	6	.14	—.09	—.09	.03
C	12	.27	.45	.20	—.41	7	.45	.12	.43	.71
G	16	.38	.09	—.30	.22	7	.43	.44	—.54	.31
He	9	.05	.42	.39	—.13	9	—.37	.17	.83	.08
Ho	13	—.41	.32	.18	.23	1	—	—	—	—
J	9	—.03	—.15	.47	—.43	6	.49	.60	.71	—.71
M	24	—.20	.08	—.31	—.27	8	.11	.12	.69	.80
S	9	—.60	—.15	.44	.49	13	.32	.38	.12	—.29

is not possible to attempt correlations involving the work of different experimenters because of the lack of uniformity in their methods of making the record.

For women, 19 of the 32 correlations are positive, while 21 of the 28 correlations are positive for men. On the whole, this test shows a distinct tendency to correlate with the other four. The positive correlation is particularly noticeable between *Shock* and *Heat*. These two are very similar in general method and they were always given one after the other in the above order.

In conclusion it may be said that the *Shock* experiment shows that:

1. Women are more apt than men to yield to the suggestion, and they do not wait so long before yielding as do the men who yield.

2. There is a positive correlation between this test and the four others with which it can be compared.

3. The correlations are more clearly positive for men than for women.

5. Conclusions Regarding the Four Tests Involving the Idea of a "Least Perceptible" Sensation

The four tests so far described all involve the same type of suggestion. Through an appeal to pride and competitive interest the subject is led to anticipate and report as the "least perceptible" a sensation for which there is no physical basis.

A majority of the persons tested yielded to all four of these suggestions. On the whole, the test with *Odors* was the most successful of them; only one person in ten could resist it. *Touch* was resisted by 28 per cent of the persons tested, and, moreover, those who did yield in *Touch* were more cautious than in *Odors*. *Shock* succeeded with a few more (only 22 per cent resisted) than *Touch*. *Heat* was the least successful of these four tests; it failed in nearly 40 per cent of the cases. The probability that the suggestion will succeed depends to some extent upon the length of time that it is kept up, and obviously the heat sug-

gestion, to which the subject was seldom subjected for more than thirty seconds, could not be expected to influence so many persons as the suggestion of odors, which was ten times repeated and continued in all for several minutes.

All four of these tests succeed with more women than men, and in all except *Heat* they succeed to a greater *extent* also with women; but in *Heat* the women who yield hesitate longer (though the difference is not great) than the men who yield. Three (all except *Heat*) of the graphs representing the distribution of different degrees of suggestibility show not only that cases of complete immunity from suggestion are more frequent among the men but that cases of extreme suggestibility are rarer. This evidence must be considered in support of the averages, which show a greater degree of suggestibility among the women. The averages by themselves are not very reliable from a statistical standpoint. Unfortunately it is not feasible, in view of the peculiar roughness of the data, even to state the degree of reliability of the averages, but the distributions indicate that the averages are not seriously misleading. Moreover, the conclusions are supported by the fact that the general averages are confirmed by the separate findings of the individual experimenters.

To some extent the indices of correlation should enable us to determine whether there is any real relationship between the members of this reputed family of tests. *Heat* shows correlations which are comparatively high (high, that is, in view of the average magnitude of the coefficients obtained between these tests) with each of the other three, and particularly with *Shock*, its nearest theoretical relative. The relationship between *Shock* and *Touch* has not been computed for lack of suitable data. *Shock* does not appear to be related to *Odors* any more closely than to tests of a wholly different type. *Touch* is more closely related to *Heat* than to any other test, notwithstanding the fact that the tests for these two experiments were made at different times and, for the most part, by different persons. *Touch* does not correlate as closely with *Odors* as with other and different tests, in spite of the strong theoretical relationship between them.

Odor gives higher correlations with other tests than with members of its own family. So far as the coefficients of correlation may be interpreted as indicating an actual resemblance between these tests which are supposed to have a theoretical relationship, they confirm the relationship between *Heat, Shock,* and *Touch,* but tend to deny it in the case of *Odors.*

Since the coefficients of correlation are, in general, more apt to be positive than negative, the results so far lend color to the theory that suggestibility is a trait such that a person who is found to be highly suggestible in one test will probably prove to be more suggestible than most persons in another test. This is certainly so if, as in the present group of tests, the different tests bear a certain amount of resemblance to one another.

III

FOUR TESTS INVOLVING THE PERCEPTION OF CHANGE

1. Brightness; 2. Pitch; 3. Size; 4. Motion

The background for three of these tests is drawn from the familiar notion of a "just perceptible change." The notion of a just perceptible motion, embodied in the fourth of these suggestions, seems closely analogous to the others when it is expressed as a "just perceptible change" of position. In all four cases the subject is given an actual perception of change upon which to build up his anticipation. In all four cases the spirit of emulation is aroused. The degree of suggestibility is measured in terms of the promptness with which the subject reports the imaginary perception after he has been told to look for it. In all of the four experiments the subject was given credit for a "failure" (i.e., immunity from suggestibility) if he resisted the suggestion for as long as two minutes.

1. Change of Brightness[10]

A color-wheel was provided by means of which the proportions between the black and white sectors of a disc could be varied while the disc was in rotation. The apparatus, except the disc, was covered by a screen, and proper precautions were observed to prevent the subject from discovering that the experimenter failed, after the preliminary demonstration, to change the sectors.

The typewritten directions which were handed to the subject were as follows:

LEAST PERCEPTIBLE CHANGE IN BRIGHTNESS

It is the object of this experiment to determine how small a change in brightness you can detect.

The experimenter will first demonstrate to you the operation of the apparatus, showing how the proportion of black and white can be changed while the wheel is in rotation.

You are to sit directly in front of the wheel. The experimenter will give you a signal when you are to begin to look for a change in the brightness of the disc. The experimenter will hold a stop-watch to see how long the change continues before you notice it.

As soon as you are sure whether the disc is getting lighter or darker you are to give a signal to the experimenter to stop the motor. Ordinarily only one trial will be given.

A conspicuous change was given by way of preparation and then the actual test was begun with the word "now". No change was then made, but the time was noted until the subject thought he saw a change, either lighter or darker. This time is taken as the index of suggestibility.

The following table gives the number of subjects and the average time of resistance as obtained by each experimenter. The figures are given without regard to the question whether the subject thought the change was toward "brighter" or toward "darker". The number of persons who refused entirely to respond to the suggestion in this test was so small that it has not been entered in the table. Four women failed to respond, one with experimenter S. and three with experimenter He., and

[10] An experiment of a similar kind was tried by Seashore, *Yale Studies*, vol. 3, 1895, p. 32.

CHANGE OF BRIGHTNESS

Experimenter	Number women	Average time	Number men	Average time
A	14	23.6	6	10.7
C	12	8.2	6	19.0
G	17	9.9	6	6.5
He	10	19.0	8	16.4
Ho	9	13.4	1	8.0
I	11	10.7	6	16.0
J	7	18.4	6	18.5
M	24	14.6	8	18.3
S	9	5.5	13	10.9
All	113	13.7	60	14.0

three men, two with experimenter M. and one with experimenter He. The number of subjects given in the table is inclusive of these recalcitrants, but the average time does not, of course, include them. This same method of tabulation will be followed in each of the three experiments following.

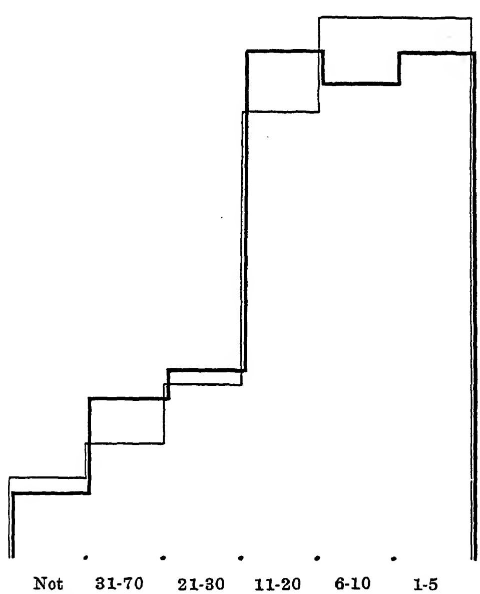


Fig. 5—Brightness. Light line, women; dark line, men.

No very marked difference in suggestibility appears between the sexes. The general average shows that the men hesitate a fraction of a second longer before yielding to the suggestion than the women, but this result is contradicted by the findings of four of the nine experimenters.

The distribution of persons according to degrees of suggestibility (fig. 5) indicates that a larger proportion of the women than of the men yield to the suggestion within ten seconds. This argues in favor of the reliability of the average figure, which shows that men resist the suggestion a little longer than women. The absolute number of persons who wholly resist the suggestion is too small to give a reliable indication of a sex difference in that direction.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures are the percentile proportion of the subjects who confessed to seeing a change after the various intervals of time.

Time	Women	Men
Not within 2 minutes	4.2	3.3
51–70 seconds	1.7	3.3
31–50 seconds	4.2	5.0
21–30 seconds	9.2	10.0
11–20 seconds	23.5	26.7
6–10 seconds	28.6	25.0
1–5 seconds	28.6	26.7

The correlations between the rankings in this test and in the other tests are shown in the following table. On the whole, there is a tendency on the part of this test to correlate positively with the other tests. Of the correlations among the subjects of the separate experimenters, the women show twenty-one positive instances to thirteen negative and the men show twenty-two positive to eight negative. Among the correlations for the larger groups, without regard to experimenter, some of the most clearly positive (*Touch* and *Weights*) are found for tests which were made at a different sitting and by different persons. The correlation is relatively high with *Change of Pitch,* which closely resembles *Change of Brightness* in general method and which

was always given immediately after it. Yet six of the seventeen correlations by separate experimenters are negative between these two tests.

Correlations Between Suggestibility in the Test With Change of Brightness and Suggestibility in Nine Other Tests

Women

Experimenter	Number cases	Touch	Odors	Heat	Shock	Pitch	Size	Motion	Lines	Weights
A	14	......	—.05	.66	.10	.20	......	......	......	......
C	12	......	—.11	.29	.20	—.06	......	......	......	......
G	16	......	—.87	.22	—.30	—.05	......	......	......	......
He	10	......	.20	.44	.39	—.10	......	......	......	......
Ho	13	......	—.14	.16	.18	.27	......	......	......	......
I	13	......	.33	—.47	—	.21	......	......	......	......
J	8	......	—.35	—.31	.47	—.14	......	......	......	......
M	24	......	.33	.09	—.31	.64	......	......	......	......
S	10	......	.00	.13	.44	.65	......	......	......	......
All	54	.15	.05	.07	—	.18	—.16	—.05	—.06	.22

Men

Experimenter	Number cases	Touch	Odors	Heat	Shock	Pitch	Size	Motion	Lines	Weights
A	6	......	.55	.26	—.09	.14	......	......	......	......
C	7	......	—.32	.65	.43	.04	......	......	......	......
G	6	......	.11	.06	—.54	—.14	......	......	......	......
He	8	......	—.28	.19	.83	.18	......	......	......	......
Ho	1	......	—	—	—	—	......	......	......	......
I	5	......	.50	—.30	—	.81	......	......	......	......
J	6	......	.57	.36	.71	—.42	......	......	......	......
M	8	......	—.22	.16	.69	.55	......	......	......	......
S	13	......	.37	.00	.12	.66	......	......	......	......
All	29	.42	.40	.04	—	.38	.09	.39	.08	.40

The following general statement may be made regarding the *Brightness* test:

1. The amount by which women exceed men in suggestibility is very small.

2. This test correlates positively with other tests.

3. The positive correlations with other tests are much greater for groups of men than for groups of women.

2. Change of Pitch

The following typewritten directions were handed to the subject.

LEAST PERCEPTIBLE CHANGE OF PITCH

It is the object of this experiment to determine how small a change of pitch you can detect.

The experimenter will first demonstrate the apparatus to you, showing how the change of pitch is produced while the whistle is blowing.

You are to sit with your back to the apparatus, so that you can not see how great a change of pitch is being produced, and listen intently to the whistle. The experimenter will hold a stop-watch to see how long the change continues before you notice it. As soon as you are sure whether the change is up or down, that is, whether the pitch is higher or lower, you are to give a signal to the experimenter to stop the whistle. Ordinarily only one trial will be given.

The subject was shown the apparatus, which consisted of a Stern *tonvariator,* by which the pitch of the metallic whistle could be altered while the whistle was being blown from a floating tank of air. He was then seated with his back to the instrument and the whistle was started at a pitch of 420 vibrations per second. A rapid and conspicuous change of pitch was then made up to 435 and back to 420. The experimenter then refilled the air tank, started the stop-watch and said "ready", while the whistle was steadily blowing but without any change of pitch. The degree of suggestibility was measured by the time the subject waited before announcing the direction of the change of pitch which he imagined he heard.

Only 4.4 per cent of the subjects (four women and four men) failed to hear a change of pitch within the two-minute period which was allowed for the suggestion to take effect. We are not prepared to say that the pitch of this whistle does not really change while it is blowing, but if it does there is little agreement among the subjects as to the direction of the change; 59 per cent of the women thought the pitch grew higher, and 53 per cent of the men thought it grew lower. The following table shows the number of persons experimented upon by each operator and the average time of the delay before responding to the suggestion.

Experimenter	Number women	Average time	Number men	Average time
A	14	16.1	6	25.7
C	12	21.0	7	17.3
G	16	13.3	7	18.3
He	11	16.1	9	22.4
Ho	11	31.1	1	28.0
I	12	21.8	6	27.0
J	9	14.1	6	16.5
M	26	8.7	8	12.2
S	9	8.8	12	15.2
All	120	15.7	62	19.4

The general average shows that women respond to the suggestion more quickly by about three and a half seconds. Seven of the nine investigators agree in finding that women respond more quickly.

The distribution of the degrees of suggestibility (fig. 6) does not show as consistent a difference between the sexes as is shown

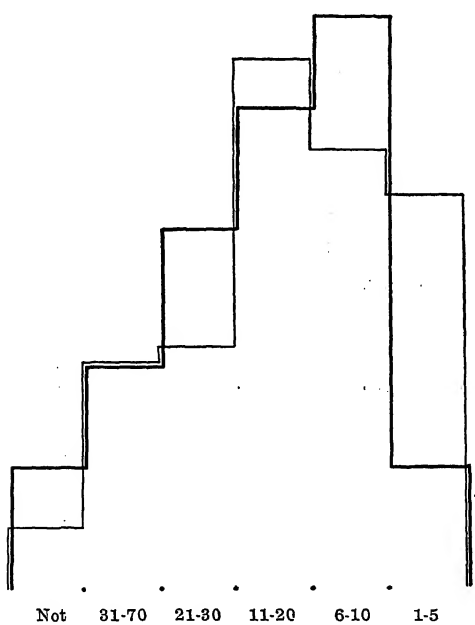


Fig. 6—Pitch. Light line, women; dark line, men.

by some of the other distributions. The men are less apt to respond within five or within ten seconds, but more men respond in from six to ten seconds. The mode for men is between six and ten seconds; yet it must be said that on the whole less men than women respond within ten seconds and that more men than women reject the suggestion for more than twenty seconds. More women than men resist for more than fifty seconds, and more men than women hold out for the entire two minutes of the test, but the absolute number of individuals concerned in these last statements is small.

Frequency of Different Degrees of Suggestibility

The figures show the percentile proportion of the subjects who confessed to hearing a change of pitch within various intervals of time.

Time	Women	Men
Not within 2 minutes	3.2	6.3
51–70 seconds	5.6	1.8
31–50 seconds	6.4	8.0
21–30 seconds	12.8	19.0
11–20 seconds	28.0	25.4
6–10 seconds	23.2	30.1
1–5 seconds	20.8	6.3

The absolute time of hesitation in this test is from two seconds (women) to five seconds (men) longer than in the test for *Change of Brightness*. But in spite of this fact the test succeeds just as well in that nearly all the persons tested yield to the suggestion within the time limit of two minutes.

The following table shows the correlation of other tests with *Change of Pitch*. Of the correlations obtained for the subjects of separate experimenters, the women give thirteen positive and twenty-one negative; the men twenty-two positive and nine negative. This test correlates comparatively closely with the analogous test in *Change of Brightness* and to some extent with *Size, Weights,* and *Touch,* but it does not correlate well with *Odors, Heat,* or *Shock,* in spite of the fact that the last-named tests were administered at the same sitting and by the same persons.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE TEST WITH CHANGE OF PITCH AND SUGGESTIBILITY IN NINE OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Heat	Shock	Brightness	Size	Motion	Lines	Weights
A	14	......	—.31	—.13	—.29	.20	......	......	......	......
C	12	......	.12	.41	—.41	—.06	......	......	......	......
G	16		.15	.28	.22	—.05	......	......	......	......
He	11	......	.06	—.23	—.13	—.10	......	......	......	......
Ho	14		.00	.45	.23	.27	......	......	......	......
I	13	......	—.30	—.19	——	.21	......	......	......	......
J	9	......	.35	.06	—.43	—.14	......	......	......	......
M	24	......	.11	.01	—.27	.64	......	......	......	......
S	9	......	.32	—.39	.49	.65	......	......	......	......
All	54	.27	.10	.29	......	.18	.04	.16	.05	.07

Men

Experimenter	Number cases	Touch	Odors	Heat	Shock	Brightness	Size	Motion	Lines	Weights
A	6	......	.25	.26	.03	.14	......	......	......	......
C	7		.57	.69	.71	.04	......	......	......	......
G	7	......	.40	.48	.31	—.14	......	......	......	......
He	9	......	.19	.32	.08	.18	......	......	......	......
Ho	1	......	......	......	......	......	......	......	......	......
I	5	......	.75	.70	......	.81	......	......	......	......
J	6		.40	.71	—.71	—.42	......	......	......	......
M	8	......	.18	.26	.80	.55	......	......	......	......
S	13	......	.05	—.01	—.29	.66	......	......	......	......
All	29	.15	.16	.06	......	.38	.46	.09	—.08	.38

The data of this experiment warrant the following general statements:

1. Nearly all persons yield to the suggestion of *Change of Pitch*, but women yield more quickly than men.

2. Suggestibility in this test is positively correlated, to a small extent, with suggestibility in other tests.

3. The correlations are much closer with groups of men than with groups of women.

3. Change of Size

An Aubert diaphragm was interposed between a light and a lens in such a way as to throw a bright square of light upon a translucent screen of waxed paper. The image was about 5 cm. square and its corners were placed in the vertical and horizontal axes. The instructions handed to the subject were as follows:

LEAST PERCEPTIBLE CHANGE OF SIZE

It is the object of this experiment to see how small a change of size you can notice. You will see a bright area on the screen. This can be made gradually larger or smaller. Watch it closely and as soon as you see any change of size tell the experimenter whether it is increasing or decreasing in size.

By opening the Aubert diaphragm with a rack and pinion the experimenter produced, for demonstration, a very noticeable increase in the size of the bright square. He then reduced the square to the original size and said "ready". No further change was made in the size of the square. The time was recorded from the word "ready" till the subject reported an increase or a decrease. This time was taken as the index of suggestibility. Two minutes were allowed for a failure.

This experiment was given at the same sitting with, and immediately after the completion of *Motion,* which will be described next. *Brightness* and *Pitch,* which have just been described, were given at a different sitting, and usually by different experimenters.

Experimenter	Number women	Average time	Number men	Average time
A	19	11.1	10	8.2
C	8	6.8	6	12.2
G	19	11.1	6	3.1
He	10	13.3	19	17.9
I	12	11.5	8	4.9
S	11	11.6	11	6.5
All	79	11.1	60	10.3

The sex differences in this experiment are very slight. More men resisted the suggestion completely (one in every 12 as com-

pared with one woman in 79), but the average time of resistance of the men (10.3 seconds) was less than that of the women (11.1). Four of the six experimenters agree with the average in finding that the men yield sooner than the women. The figures are given in the table on the opposite page.

The distributions according to degrees of suggestibility (fig. 7) show that the men are more apt to yield within five seconds, and also, as stated above, more apt to resist completely. The distribution is not unlike that for *Brightness,* except that a larger proportion of all the cases fall within the first ten seconds.

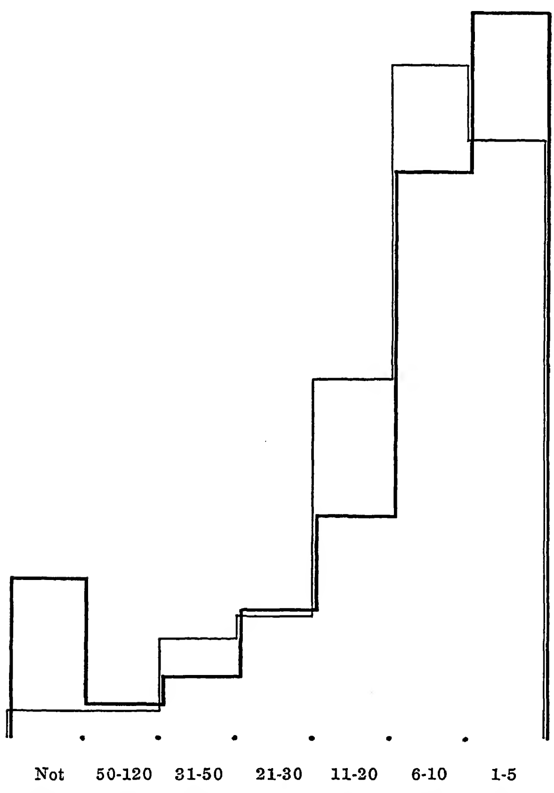


Fig. 7—Size. Light line, women; dark line, men.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who confessed to seeing a change of size within various intervals of time.

Time	Women	Men
Not within 2 minutes	1.3	8.3
51 seconds or more	1.3	1.7
31–50 seconds	5.1	3.3
21–30 seconds	6.3	6.7
11–20 seconds	19.0	11.7
6–10 seconds	35.5	30.0
1–5 seconds	31.6	38.4

The absolute time which elapses before the average individual yields to this suggestion is somewhat less than for *Brightness* or *Pitch*, yet the number of total failures is larger.

The correlations between this and other tests, as shown in the following table, are generally positive. Those based on ranking 29 men and 54 women, without regard to experimenter, in this

CORRELATION BETWEEN SUGGESTIBILITY IN THE TEST WITH CHANGE OF SIZE AND SUGGESTIBILITY IN EIGHT OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Motion	Lines	Weights
A	19	.01	......	......	......	......	.42	.49	.17
C	7	—	......	......	......	......	.21	—	—
G	19	—.10	......	......	......	......	—.13	—.21	.12
He	10	.19	......	......	......	......	.73	—.01	.21
I	12	.12	......	......	......	......	.62	.68	—.05
S	11	.07	......	......	......	......	.45	—.40	.53
All	54	.04	.08	.04	—.16	.04	.12	.06	.27

Men

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Motion	Lines	Weights
A	10	.16	......	......	......	......	.70	.04	.29
C	5	—	......	......	......	......	.98	—	—
G	6	.20	......	......	......	......	.94	—.03	—.09
He	19	.33	......	......	......	......	.83	.47	—.12
I	7	.34	......	......	......	......	.45	.84	—.34
S	11	.35	......	......	......	......	.08	.53	.09
All	29	.30	.39	.26	.09	.46	.36	.17	.22

and eight other tests give only one negative instance for the women and no negative instance for the men. The correlations for the separate experimenters, in this and four other tests, show fifteen positive to six negative cases for the women and seventeen positive to four negative for the men.

The correlation is high with *Motion,* which was performed at the same time and by the same persons and according to an almost identical method; but it is also high with *Odors,* which was as different as possible in method, and performed at a different time and, usually, by different persons. The correlation is much closer with *Pitch* than with *Brightness,* although both of these experiments seem to rest upon much the same methods as were employed in the present experiment.

The general conclusions for this experiment may be stated as follows:

1. No clear sex difference in suggestibility appears. Although men tend to yield sooner than women to the suggestion, more men also succeed in completely resisting it.

2. There is a positive correlation between this test and nearly all of the others.

3. The correlations are much higher for men than for women.

4. Motion[11]

A strip of medium gray paper was stretched from the picture moulding to the floor in a partially darkened room. A disc of light, just bright enough to be clearly visible on the background of the paper, was projected upon the middle of the paper. The disc was 5 cm. in diameter and was about 3 meters away from the subject, a little above the level of his eyes. The directions were as follows:

LEAST PERCEPTIBLE MOTION

It is the object of this experiment to find how small a motion you can see. You will see a small circle of light on the wall. This light can be raised or lowered. Watch it closely and as soon as you see any motion tell the experimenter whether it is going up or down.

[11] The experiment of Small, *Ped. Sem.*, vol. 4, 1896, p. 182, with the toy camel bears some resemblance to this one.

For demonstration the disc was made to rise about 15 cm by turning the crank of an elevating stand upon which the ligh stood. It was then lowered to the starting point. Then th experimenter said "ready" and began to turn the crank of an other stand, making the same noise as that made when the ligh was really moved. Time was recorded from the word "ready" till the subject reported motion. The test was considered a failure if no motion was reported within two minutes. Of 79 women, only three failed to see a change within half a minut and none resisted for two minutes. Of 58 men, nine failed to see a motion within half a minute, and of these six held ou beyond the two-minute limit, but it should be noted that five o the six were reported by one experimenter (He.).

Experimenter	Number women	Average time	Number men	Average time
A	19	11.0	10	13.9
C	8	9.5	5	10.4
G	19	12.0	6	5.7
He	10	10.0	19	14.5
I	12	12.9	7	6.2
S	11	8.7	11	9.0
All	79	10.9	58	10.8

The average time of resisting the suggestion is greater for the women by a very slight amount, although four of the six experimenters found the time longer for the men.

The distribution of the degrees of suggestibility, shown in figure 8, indicates that a larger proportion of the women yiel to the suggestion within five seconds and that none of them resist for the whole two minutes of the test. A comparatively large proportion of the men hold out against the suggestion for the entire two minutes.

Women appear to be slightly more suggestible than men in this experiment, although the simple average gives an indicatio the other way.

With respect to the absolute time required before the suggestion becomes effective, and to the general form of the curves

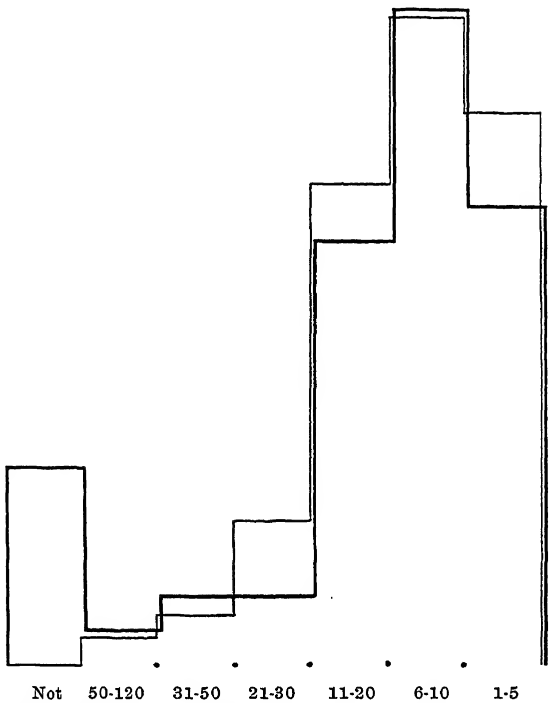


Fig. 8—Motion. Light line, women; dark line, men.

of distribution of degrees of suggestibility among individuals, this experiment tallies very closely with the one on *Change of Size*. The superficial resemblance of the two experiments seems

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who confessed to perceiving motion within various intervals of time.

Time	Women	Men
Not within 2 minutes	0.0	10.3
51 seconds or more	1.3	1.7
31–50 seconds	2.5	3.5
21–30 seconds	7.6	3.5
11–20 seconds	25.3	22.4
6–10 seconds	34.2	34.5
1–5 seconds	29.1	24.2

to be confirmed by the data. There is also a relatively high degree of correlation between ranking in *Size* and in *Motion*.

The correlations for this test are shown in the following table. For the group of 54 women, without regard to experimenter, there are five of the eight correlations which are negative. In spite of these negative correlations for the women, there are no negative correlations for any of these eight tests among the corresponding group of 29 men. Of the separate correlations for the subjects of particular experimenters, there are sixteen positive to five negative cases for the men. The women show twelve positive to nine negative.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE TEST WITH MOTION AND SUGGESTIBILITY IN EIGHT OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Size	Lines	Weights
A	19	.24	......	......	......		.42	.13	.04
C	7	—	......				.21		
G	19	.22	......	......	......		.13	.29	.08
He	10	.45	......				.73	.19	.35
I	12	—.33	......	......	......		.02	.05	.31
S	11	.06	......	......			.45	.60	.06
All	54	.07	—.28	.24	—.05	.16	.12	.20	.24

Men

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Size	Lines	Weight
A	10	—.05	......				.70	.23	.42
C	5	—	......				.98		
G	6	.14	......				.94	.03	.20
He	19	.51	......				.83	.63	.09
I	7	.57	......				.45	.58	.13
S	11	—.40	......				.08	.53	.20
All	29	.19	.14	.09	.39	.09	.36	.23	.18

The only test which shows a good positive correlation with *Motion* for both men and women is *Size*. *Pitch* and *Touch* are the only others for which a positive correlation is found among

women. *Brightness* gives a high positive figure for men and a small negative figure for women.

No conclusions of much value can be drawn from this experiment:

1. Women are perhaps more suggestible.

2. While men show a positive correlation between this and most other tests, women do not.

5. The Direction of the Imaginary Change

A curious phenomenon in connection with the experiments involving the suggestion of an imaginary change is that the suggestion seems to work more effectively in one direction than in the other. For example, a change of brightness is more apt to appear as an *increase* than as a *decrease*; the disc seems to become lighter more often than it seems to become darker. The data on this point are combined for the four experiments in the following table:

	Number women	Average time	Number men	Average time	Total cases	Average time
Brightness "lighter"	64	14.5	42	13.5	106	14.4
Brightness "darker"	47	11.4	17	13.6	64	12.0
Pitch "up"	69	13.9	27	15.7	96	14.4
Pitch "down"	47	18.4	31	22.7	78	20.2
Size "increase"	46	10.6	36	10.4	82	10.5
Size "decrease"	28	12.6	16	10.9	44	12.0
Motion "up"	52	10.9	22	13.2	74	11.6
Motion "down"	24	11.4	27	9.2	51	10.2

The figures indicate a marked tendency to favor the judgment of "increase" or "up". No clear difference is apparent between the sexes with regard to this tendency, although two exceptions to the general rule are found in the masculine groups. On the whole, there is evidence that the more favored response is given with less hesitation, that is, in a shorter time, than the less favored response. Exceptions are found in the case of the women in *Brightness* and the men in *Motion*. In the latter case

the total for men and women together becomes an exception to the general rule through the magnitude of the exceptional figures for the men.

If an interpretation of this phenomenon is sought it may be found in the fact that the "increase" or "up" direction of change was always mentioned first in the directions which were put into the subjects' hands, or in the further fact that the same direction of change was always used first in giving the demonstration of an actual change before the test. The diversity of the experimental material makes it highly improbable that the phenomenon springs from purely sensory sources. Such an explanation readily suggests itself for one or another of the experiments singly, but would scarcely account for the rather uniform effects in all of the experiments together. It is possible that the preference for one judgment rather than the other depends upon a deep-seated central tendency whereby the mental machinery is prepared to give expression to one notion more readily than the other in the absence of any outer change in the situation.

6. Conclusions Regarding the Four Tests Based on the Idea of a "Least Perceptible" Change

These four experiments permit of a very close comparison, not only with respect to the form of the suggestion but also with respect to the measurement of suggestibility. They all rest upon the familiar notion of a "just perceptible change"; they are all reinforced by a demonstration of actual change, and they are all scored by the lapse of time before the suggestion takes effect.

The four experiments are all successful in securing an almost uniform acceptance of the suggestion. Moreover, the suggestion is accepted very promptly. The following table shows the average time elapsing before the subject yielded to the suggestion, the proportion of the subjects who accepted the suggestion within ten seconds, and the proportion of the subjects who refused to accept the suggestion within two minutes.

This group of experiments does not reveal a very clear sex difference in suggestibility. Considering the average time of

	Average time	Per cent yielding within 10 secs.	Per cent resisting over 2 min.
Brightness	13.8 secs.	55%	3.9%
Pitch	16.9	41	4.3
Size	10.7	68	4.3
Motion	10.9	61	4.4

resistance, the number of refusals, and the proportion of quick responses, it appears that the women are more suggestible in *Pitch* and less clearly so in *Brightness*. *Size* shows a briefer resistance but also a larger proportion of total refusals among the men. *Motion* gives no positive difference, although the distribution shows more women yielding within five seconds and fewer resisting for two minutes. Taken as a group, the four tests show women somewhat more open to suggestions of this type than men.

The correlations indicate that the theoretical relationships between the four tests of this group are reflected in the effects upon the subjects. *Pitch* is more closely correlated with *Brightness* than with any other test; its next closest correlation is with *Size*, and it is positively correlated, for both men and women, with *Motion*. *Brightness*, however, has other correlations stronger than that with *Pitch*, while its correlation with *Motion* is not close, and with *Size* the poorest of all. *Size* is closely (as these figures go) correlated with *Motion* and *Pitch*, but not with *Brightness*. *Motion* and *Size* are closely correlated, but all the other correlations for *Motion* are very uncertain on account of the very low coefficients obtained from the women and the very much better figures obtained from the men. On the whole, the relation of the two pairs, *Pitch* with *Brightness* and *Motion* with *Size*, stands out clearly. Further, *Pitch*, *Size*, and *Motion* seem to be interrelated, but *Brightness* does not seem to be closely related to any of them except *Pitch*. While these four tests really seem to constitute a family group, it must be acknowledged that their relationships within the group are not much stronger than some of their relationships outside the group, and in the case of *Motion* not so strong.

Although these tests do not afford many high coefficients of correlation with other tests, positive figures occur more frequently than negative ones. This seems to indicate, so far as it goes, that suggestibility is a trait of such a kind that if a person proves suggestible in one of these tests he is more apt than not to prove suggestible in other tests. Since the coefficients are much higher for men than for women, the above conclusion is much more probably correct for men than for women.

IV

TWO TESTS DEPENDING UPON A SERIES OF PROGRESSIVE INCREASES

1. Progressive Weights; 2. Progressive Lines

These tests were made as nearly alike as possible in method and in scoring. The idea in the background in the directions was "least perceptible difference" or "delicacy of discrimination." The real source of the suggestion seems, however, to be the actual series of increases with which the experiment begins. The method of scoring was adapted to the purpose of obtaining exactly comparable scores from the two experiments.

1. Progressive Weights[12]

Fifteen black tin boxes of uniform appearance, but marked on the top in a conspicuous manner with numbers, in order, from one to fifteen, were placed in a row on a table. The actual weights of the first five were 20, 40, 60, 80, and 100 grams, and all the others were 100 grams. The directions which were handed to the subject were as follows:

DISCRIMINATION OF WEIGHTS

This experiment is intended to test your ability to distinguish between weights. Lift the weights, one after the other, as directed by the experi-

[12] This experiment is Binet's (*La suggestibilité*, pp. 161–208). The directions, material and method of scoring are according to Whipple, *Manual of Mental and Physical Tests*, p. 410, edition of 1910.

menter, beginning on the left. As you lift each weight say whether it is heavier, lighter, or the same as the one just before it. All that you have to say is either "lighter", "heavier", or "the same." Remember you are to compare each weight with the one lifted just before. Do not lift any weight more than once.

The experimenter indicated to the subject the manner of lifting the weight between the thumb and fingers. It is very hard to make the subjects follow the directions in this experiment, and more verbal explanations were required than is desirable; but once the subject had got fairly started there was no difficulty in making the judgment.

There were ten judgments upon weights which were really all the same. The index of suggestibility was obtained by counting the number of judgments "heavier" which occurred among the judgments on these ten weights. The table below indicates that women are more apt than men to continue saying "heavier" when there is no longer any difference between the weights. The average result is confirmed by the findings of four of the six experimenters.

Experimenter	Number women	Average number "heavier"	Number men	Average number "heavier'
A	19	4.3	10	3.6
C	9	4.8	6	4.1
G	19	4.1	6	4.1
He	10	5.2	19	4.1
I	12	4.4	8	4.9
S	11	4.9	11	3.7
All	80	4.5	60	4.05

As some objection may be raised to the method of scoring, on the ground that no account has been taken of the number of times the weights were judged equal, it may be added that the average woman calls the weights equal 3.5 times, while the average man calls them equal 3.7 times in ten trials. This indicates that the index according to positive cases, as given above, does not seriously misrepresent the actual sex difference.

The distribution of persons according to different degrees of suggestibility, shown in figure 9, reinforces the inference from

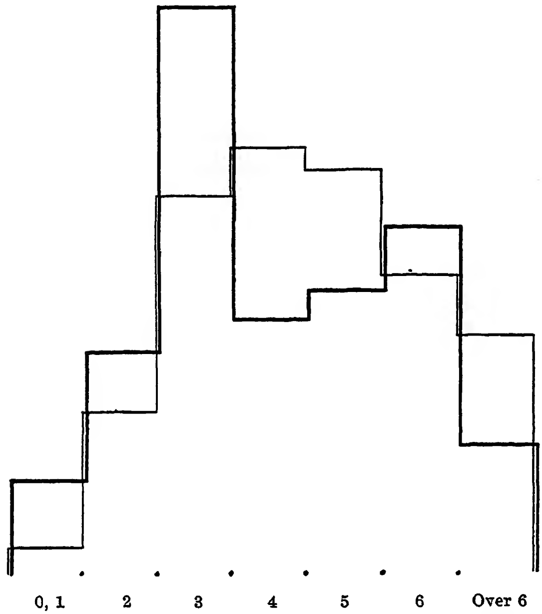


Fig. 9—Progressive Weights. Light line, women; dark line, men.

the average that women are more suggestible than men in this experiment. More men say "heavier" only three times or less (47 per cent as compared with 30 per cent). More women say "heavier" seven times or more (12.5 per cent to 6.7 per cent). The mode for the women is four judgments of "heavier", that for the men three.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who reported "heavier" 0, 1, 2, 3, etc., times among the 10 trials with equal weights.

Times	Women	Men	Times	Women	Men
0	1.3	1.7	6	13.8	18.3
1	0.0	3.3	7	5.0	5.0
2	8.6	11.7	8	7.5	0.0
3	20.0	30.0	9	0.0	1.7
4	22.5	13.3	10	0.0	0.0
5	21.3	15.0			

The correlations between ranking in *Weights* and other tests is shown in the following table. In the groups of 54 women and 29 men the women give two negative correlations out of eight (*Touch, Motion*) and the men one (*Heat*). The correlation is unusually high with *Brightness, Pitch,* and *Size;* and positive, but not high, with the closely analogous test of *Progressive Lines.* Particular interest attaches to the high correlation with *Brightness* and *Pitch,* not only because these tests involve another method and were given by different experimenters at a different time but also because their suggestion is addressed to sight and hearing respectively, while the suggestion of *Weights* is addressed to a different sense. The correlation is negative for the women and not high for the men with *Touch,* which is addressed to the same, or to a closely related, sense. Perhaps it should be noted, however, that the conspicuous numbers on the tops of the weights make a strong appeal to the eye. Of twenty-one correlations for separate experimenters thirteen are positive for women and the same number for men.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE EXPERIMENT WITH PROGRESSIVE WEIGHTS AND SUGGESTIBILITY IN EIGHT OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Size	Motion	Lines
A	19	—.24	......	......	......	......	.17	.04	.44
C	9	—	......	......	......	......	—	—	.41
G	19	.05	......	......	......	......	.12	—.08	.05
He	9	.68	......	......	......	......	.21	.35	—.08
I	12	—.08	......	......	......	......	—.05	—.31	—.07
S	11	.04	......	......	......	......	.53	.06	—.05
All	54	—.13	.18	.05	.22	.07	.27	—.24	.17

Men

Experimenter	Number cases	Touch	Odors	Heat	Brightness	Pitch	Size	Motion	Lines
A	10	—.20	......	......	......	......	.29	.42	.01
C	5	—	......	......	......	......	—	—	.90
G	6	—.46	......	......	......	......	—.09	—.20	—.46
He	19	.08	......	......	......	......	—.12	.09	.05
I	7	.24	......	......	......	......	—.34	.13	—.44
S	11	.08	......	......	......	......	.09	.20	.13
All	29	.11	.16	—.16	.40	.38	.22	.18	.16

The final statement for this test may be put in the following way:

1. Women are undoubtedly more suggestible than men.
2. There is a positive correlation between this test and others, and the correlation is not lower for tests given by a different method, by different persons, at a different time, and addressed to a different sense organ.
3. The correlations are higher with groups of men than with groups of women.

2. Progressive Lines[13]

This experiment corresponds very closely to the one with *Progressive Weights,* just described. They were given by the same experimenters at the same sitting, but another test intervened between them. The directions which were handed to the subject read as follows:

ESTIMATION OF LENGTH OF LINE

It is the purpose of this experiment to test your ability to estimate the length of short lines. You will see one line at a time and you are to reproduce it right afterward from memory. Take one look at the line and then make a mark on the cross-section paper just the distance from the left-hand edge that the line is long. Then say "ready" and the next line will be shown you. Make your estimate of it just under your estimate of the last line. And so on for all of the twenty lines.

The lines were drawn very black on glazed white paper and attached to a drum which could be revolved. They were exposed, one at a time, through a horizontal slit in a screen. The estimates were made on every fifth line of a sheet of millimeter co-ordinate paper. All the preceding estimates could be seen when a new one was made. The actual lengths of the first five lines were 12, 24, 36, 48, and 60 mm., and all the rest were 60 mm.

In order to make the results comparable with those of the last experiment (*Weights*), suggestibility was measured in terms

[13] This experiment is Binet's (*La suggestibilité,* pp. 83–160). The material and directions are according to Whipple; *Manual of Mental and Physical Tests,* p. 414, edition of 1910. The method of scoring has been changed to conform with that used in the experiment with *Progressive Weights.*

of the number of estimates, among the ten following the last actual increase, which were greater than the estimate of the preceding line. Such an increase in the estimate corresponds to the judgment "heavier" in the *Progressive Weights*. It will be noticed that in this manner of scoring no account is taken of the last five estimates. They were included in the programme of the work before it was realized that they would not be wanted.

According to the table below, there is no sex difference in the average number of lines which are drawn longer than the one just before, but it may be noted that four of the six separate experimenters find the women more suggestible in this respect.

Experimenter	Number women	Average number "longer"	Number men	Average number "longer"
A	19	3.6	10	4.7
C	9	3.7	5	4.2
G	19	3.6	6	3.3
He	9	4.3	19	3.8
I	12	4.8	7	4.3
S	11	5.1	11	4.2
All	79	4.1	58	4.1

The average woman makes the lines equal more times than the average man (2.8 to 2.6), but makes them decrease less times (3.1 to 3.3). In other words, the men do not make the lines equal quite so often, but they make them shorter enough more times so that the number of *increases* is the same for men as for women.

The distribution of persons according to degree of suggestibility, shown in figure 10, does, however, indicate that women are somewhat more suggestible than men. The mode for the women

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who drew a certain number of lines longer than the line just preceding.

Lines	Women	Men	Lines	Women	Men
0	0.0	1.7	5	34.2	24.2
1	3.8	8.6	6	8.9	8.6
2	10.1	6.9	7	1.3	1.7
3	16.5	25.9	Over 7	0.0	0.0
4	25.3	22.4			

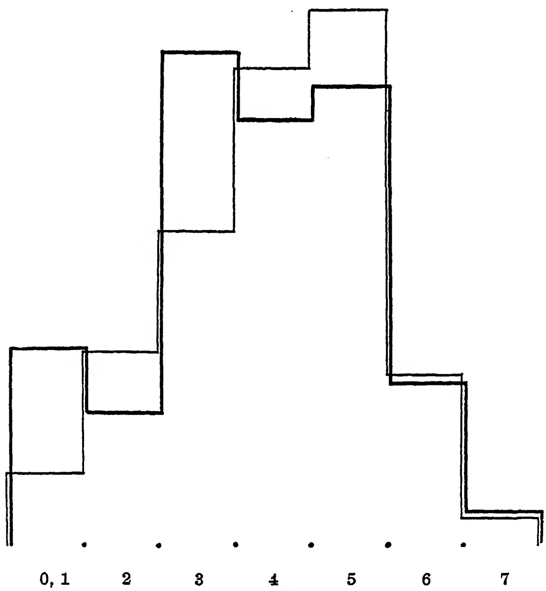


Fig. 10—Progressive Lines. Light line, women; dark line, men.

is higher than the mode for men, and there are more men who give only a very small number of increases.

Other methods of scoring may be used in this experiment. For example, the ratio may be calculated between the last of the increasing lines and the longest estimate made for one of the equal lines which follow. The figures of the following table show the results of a computation of the ratio between the average length of the fifth line (the last of the increasing lines) and the average length of the longest line given as an estimate of one of the following 15 lines (all of which were really equal to the fifth).

Experimenter	Women	Men
A	1.15	1.18
C	1.30	1.23
G	1.22	1.14
He	1.21	1.14
I	1.16	1.18
S	1.19	1.17
All	1.20	1.16

According to these figures, in which the general average is substantially supported by the findings of the separate experimenters, the women are more suggestible in the sense that they are more likely to draw some one line of the fifteen equal lines considerably longer than the standard. It is interesting to note that the average estimate of the 60 mm. standard was much too low. It was 44.3 mm. for the women and 45.4 for the men. The actual length of the sporadic longest line is, in the average, practically the same for men and women (women 53.0 mm., men 52.9). It is evident, then, that the women are not induced by the suggestion to draw a line which is absolutely longer than that of the men, but only one which is longer by comparison with the very inaccurate estimate of the fifth line.

The coefficients of correlation between the ranking in this test (on the basis of the number of estimates which show an increase) and the ranking in other tests is shown in the following table.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE EXPERIMENT WITH PROGRESSIVE LINES AND SUGGESTIBILITY IN EIGHT OTHER TESTS

Women

Experimenter	Number cases	Touch	Odors	Heat	Pitch	Brightness	Size	Motion	Weights
A	19	—.06	......	......	......	......	.49	—.13	.44
C	9	—	......	......	......	......	—	—	.41
G	19	.44	......	......	......	......	—.21	—.29	.05
He	9	—.06	......	......	......	......	—.01	—.19	—.08
I	12	.42	......	......	......	......	.68	—.05	—.07
S	11	.47	......	......	......	......	—.40	—.60	—.05
All	54	.14	.28	.15	—.06	.05	.06	—.20	.17

Men

Experimenter	Number cases	Touch	Odors	Heat	Pitch	Brightness	Size	Motion	Weights
A	10	.06	......	......	......	......	.04	—.23	.01
C	5	—	......	......	......	......	—	—	.90
G	6	.03	......	......	......	......	—.03	—.03	—.46
He	19	.60	......	......	......	......	.47	.63	.05
I	7	.08	......	......	......	......	.84	.58	—.44
S	11	.18	......	......	......	......	.53	.53	.13
All	29	.17	.24	.04	.08	—.08	.17	.23	.16

The best correlation is with *Odors*, a wholly unrelated test. The correlation with *Weights* is fairly high, but not as high as might be anticipated in view of the close relationship in method between the two tests. This test does not give a positive correlation with *Brightness* or *Pitch* in spite of the fact that *Weights*, its theoretical relative, has a high correlation with those tests. On the whole, the supposed relationship of *Lines* and *Weights* is not well supported by the correlations.

The chief conclusions from this test are:

1. Women appear to be somewhat more suggestible than men.
2. The correlations with other tests are for the most part positive.
3. The correlations are higher for men than for women.

3. Conclusions Regarding the Two Experiments Involving a Series of Progressive Changes

These experiments are successful in so far as they afford what has the appearance of being a measure of the suggestibility of nearly every person tested. Only two individuals among 140 escaped wholly from the suggestion of *Progressive Weights*, and only one among 137 from *Progressive Lines*.

In spite of the close external resemblance of the two tests, the coefficients of correlation do not indicate that they are particularly apt to affect the same persons in a similar manner. Each of them is correlated more strongly with other tests than with its mate, and the two of them do not show high correlations with the same tests.

On the whole, the two tests show positive correlations with other tests, but this is not so true for women as for men.

Both tests make women appear more suggestible than men.

Owing to the fact that a larger number of men prove comparatively resistant to the suggestion, the groups of women, as represented in the distributions, are more compact than the groups of men. The women present a more distinct single mode.

V

FIVE EXPERIMENTS INVOLVING MEMORY, RECOGNITION, AND IMAGINATION

1. Recognition of Form (Checkerboard); 2. Recognition of Position (Letters); 3. Recognition of Size; 4. Memory for Pictures; 5. Ink-Blot Test for Imagination

These tests have little or no theoretical relationship. They are grouped here for convenience in presentation. The measurements obtained in most of them are of such a nature that it is not possible to calculate correlations between them, or with other tests.

1. Recognition of Form (Checkerboard)[14]

The directions for this experiment were as follows:

MEMORY FOR SPACE RELATIONS

It is the purpose of this experiment to test the accuracy of your memory for simple space relations.

A design will be shown you in which there are six small circles. You are to observe the absolute and relative locations of these circles so that when you take another card of the same size you can mark in the exact locations of the circles.

Try to put the circles in exactly the same positions on the second card that they had on the first card.

The first card was marked with a checkerboard of five lines 34 mm. apart and with circles 6 mm. in diameter drawn on the intersection of certain of the lines, as in figure 11. This was exposed for fifteen seconds; and after it had been withdrawn, a second card of the same size was shown. The second card was marked with a checkerboard of seven lines, as in figure 12. If the circles were marked on any of the intersections of lines in

[14] This experiment was developed on the basis of W. McDougall's "Spot pattern test." See Burt, C., *Brit. Journ. Psychol.*, vol. 3, 1909, p. 150.

this second figure, neither the absolute nor the relative position of the circles would be the same as in the first figure. The subject is held to be suggestible in this experiment if he places the circles on the intersections of lines. He is held to be suggestible even though he may be aware that the figure when completed is not exactly the same as the standard.

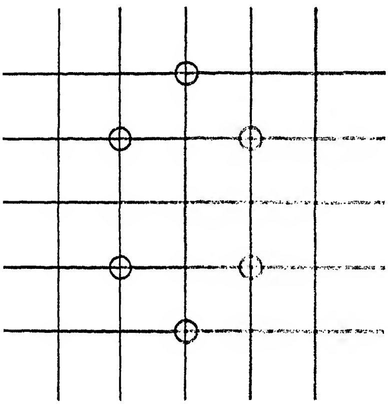


Fig. 11

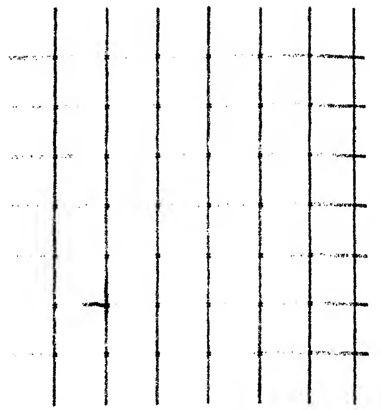


Fig. 12

The following table shows, for each experimenter, the number of persons tested and the number who succeeded in resisting the suggestion. Less than 22 per cent of the women resisted, while over 37 per cent of the men resisted. The validity of the total figures is attested by the fact that only one of the six experimenters found men more suggestible. The conclusion seems assured that women are more open to this suggestion than men.

Experimenter	Number women	Number resisting	Number men	Number resisting
A	19	4	10	1
C	8	3	5	4
G	19	3	6	3
He	9	0	19	7
I	12	4	8	2
S	11	3	11	5
All	78	17	59	22

The measurements do not permit of calculating a correlation between this test and others. The relationship of suggestibility in this to suggestibility in the next test (*Recognition of Position*) will be discussed in the next section.

2. Recognition of Position (Letters)

The title of this experiment is a misnomer, for no recognition is really involved. It is rather a case of false recognition. The actual situation may be better understood by reading the directions which were handed to the subject.

MEMORY FOR POSITION

It is the purpose of this experiment to test the accuracy of your memory for position.

A card will be shown you on which there are twelve letters. Observe it closely, noting the positions of the letters. After you have had a short look at this card another will be shown to you, and you will be asked to tell from memory which of the letters are in the same position as on the first card.

The letters were plain Roman capitals 41 mm. high, arranged in three rows of four letters each on a card 18 by 20 cm. The first card contained the letters shown in the left-hand combination below. The second card contained the letters in the right-hand combination.

C	F	L	D		D	W	G	Q
J	X	G	K		P	L	B	H
N	V	T	R		T	K	M	Z

The first card was exposed for fifteen seconds, and immediately replaced by the second. Although five letters appear on the second card which appeared on the first card, there is no letter which appears in the same position on both cards. Suggestibility is measured by the number of letters falsely recognized as being in the same position on the second card.

The following table gives the number of subjects tested by each experimenter and the proportion of the subjects who failed to respond to the suggestion, together with the average number of letters which the suggestible subjects thought they recognized.

Experimenter	Number women	Per cent failures	Average number letters	Number men	Per cent failures	Average number letters
A	19	15.8	3.6	10	10.0	3.0
C	9	33.3	2.0	6	50.0	2.7
G	17	35.3	1.8	5	40.0	1.7
He	10	60.0	1.8	19	36.8	1.7
I	12	58.3	1.4	8	37.5	2.6
S	11	54.6	1.8	11	72.7	1.7
All	78	39.8	2.40	59	40.7	2.23

In the average, women appear to be more suggestible than men. Fewer women are able to resist the suggestion, and those who yield to it report a larger number of letters than the men.

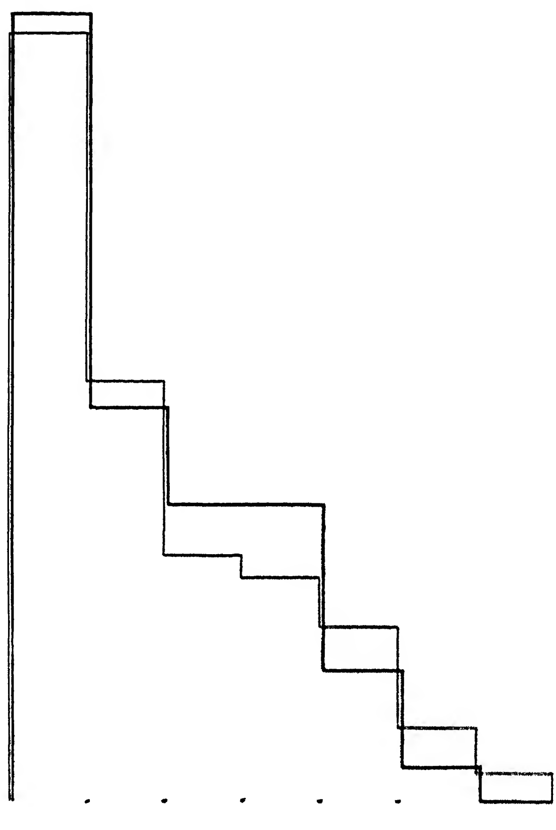


Fig. 13.—Position of Letters. Light line, women; dark line, men.

But little confidence can be placed in the average because of the great differences between the findings of different experimenters. The separate experimenters do not report a consistent sex difference in suggestibility. Yet an inspection of the distribution of the persons according to the number of letters they thought they recognized tends to increase one's confidence in the sex difference indicated by the average figures.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who thought they recognized 0, 1, 2, 3, etc., letters as being in the same position on the second as on the first card.

Number letters	Women	Men	Number letters	Women	Men
0	39.7	40.7	4	9.0	6.8
1	21.8	20.3	5	3.8	1.7
2	12.8	15.3	6	1.3	0.0
3	11.5	15.3	Over 6	0.0	0.0

Individuals who report a comparatively large number of letters (four or more) are more common among the women than among the men. On the whole, it seems probable that women are more suggestible than men in this test.

The measurements are not sufficiently delicate to warrant the calculation of correlations with other tests, but a direct comparison of the "failures" (i.e., cases of immunity from suggestion) in this experiment with the failures in the preceding one (*Recognition of Form*) gives the following figures:

	Women	Men
Number who failed in *Checkerboard*	17	21
Number who failed in *Letters*	30	24
Number who failed in *both* tests	5	10
Per cent of those who failed in *Checkerboard* who also failed in *Letters*	29%	48%
Per cent of all persons who failed in *Letters*	40	41
Per cent of those who failed in *Letters* who also failed in *Checkerboard*	17	42
Per cent of all persons who failed in *Checkerboard*	22	37

These figures show that a woman who failed to respond to the suggestion in one of these tests is not so apt as the average woman to fail to respond in the other test. But a man who fails in one is a little more apt than the ordinary man to fail in the other. Thus we have a phenomenon of the same order as that which makes the correlations generally higher for men than for women. For the men it may be said that those who prove suggestible in one of these tests probably will prove suggestible in the other, but the same statement can not be made for the women.

3. RECOGNITION OF SIZE (SQUARES)[15]

The directions were as follows:

MEMORY FOR SIZE

It is the purpose of this experiment to measure the accuracy of your memory for size.

The experimenter will first show you a white square on a black card. You are to observe this closely, trying to remember how large it is.

Then the experimenter will withdraw the card and will show you a board on which there are a large number of squares like the one on the card. You are to look them over and indicate the one which seems to be the same size as the one on the card.

This experiment is repeated with each of three standard squares and with each of three sets of squares on the boards.

The three standard squares were all of the same size (a 10 cm. square of white bristol mounted on a half sheet of black bristol), but the subject saw that there were three of them; and as he had no opportunity of comparing them he might infer that they were different. The squares from which the choice was to be made were mounted on three black boards 8 inches wide. The boards were exposed standing on end against the wall, the largest square at the bottom. The first board shown contained squares ranging from 6 cm. to 14 cm. by steps of a half centimeter. This will be referred to as the "medium" board. The "small" board

[15] The plan of this experiment is derived from Hollingworth's study of the "indifference point" (Hollingsworth, H. L., "The central tendency of judgment," *Journ. Philos., Psychol., etc.*, vol. 7, 1910, p. 461). The same idea is to be found in the recognition of length experiment of Binet (*La suggestibilité*, p. 62).

was shown next; it contained squares ranging from 3.5 cm. to 11.5 cm. Finally, the "large" board, containing squares ranging from 8:5 cm. to 16.5 cm., was shown. The relative sizes of the boards is shown in figure 14. The 10-cm. standard square is marked *right* in each part of the figure. The standard 10-cm. square on the card was shown for fifteen seconds each time just before exposing each of the boards.

It is not quite certain in this experiment how a person would respond if he were really "suggestible" or how he would respond if he were not "suggestible". It is open to question, indeed, whether this experiment really involves suggestion at all. It

Medium Small Large

Fig. 14—The position of the 10-cm. square on each of the three boards is shown by the word *Right*.

differs from all of the others in that it rests upon an extremely theoretical assumption. The assumption which was made, whether justly or not, was that a suggestible person would tend to select a square toward the middle of the series on the board from which the selection was being made. Upon this assumption "suggestibility" was measured, in the case of the "small" and "large" boards, on the basis of the choice made on the "medium" board, with the further assumption that the "constant error" of memory would be approximately the same for the other boards as for the medium one. The square selected on the medium board is taken as the datum point for each person. With that to start from, we know what card ought to be chosen on each of the other boards (assuming that the subject ought to select a square of the same absolute size every time). The following figures show what proportion of the subjects actually chose the size which they "ought" to have chosen and what proportion chose a card nearer to the center of the set or farther from the center of the set.

PER CENT OF PERSONS CHOOSING THE "RIGHT" SQUARE, OR ONE TOO NEAR THE CENTER OF THE SET, OR ONE TOO FAR FROM THE CENTER OF THE SET

	"Right"	Too near center	Too far from center
Women, set of small squares	31%	41%	28%
Men, set of small squares	24	40	35
Women, set of large squares	21	63	15
Men, set of large squares	21	63	16

The figures show that it is a fact that the choice is more apt to fall too near the center of the set than too far from it. The tendency toward the center of the set appears in both the "large" and the "small" sets, although this involves choosing too large a square in one case and too small a one in the other case. It is noticeable, however, that the tendency toward the center of the set is much stronger in the set of large squares than in the set of small ones.

Upon the assumption which has been made regarding the effect of the suggestion, it is not possible to make out a distinct

sex difference with regard to the number of individuals who respond to the suggestion. The proportion of individuals who choose a square too near the center of the set is almost exactly the same for men as for women.

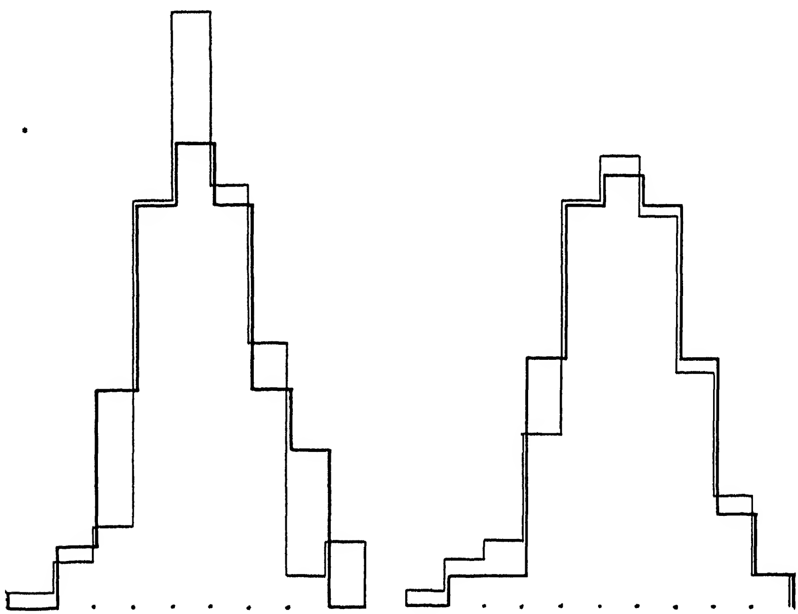


Fig. 15 Fig. 16

Figs. 15 and 16 Size of Squares. Fig. 15, small squares; fig. 16, large squares. Light line, women; dark line, men.

The graphs for the distribution of the judgments (figs. 15 and 16) show the characteristic excess of choices too near the center, but do not indicate a sex difference of any consequence. In the following table the "right" square is the one which would have been chosen if the subject had made the same absolute error in the "small" or "large" set that he made in the "medium" set. The table then shows the number of choices, 1 step, 2 steps, 3 steps, etc., in either direction from the "right" choice. Each step is to the next card in the series, that is, 5 mm.

Steps from "right"	Small squares Women	Small squares Men	Large squares Women	Large squares Men
4 too far from center	0.8%	0.0%	0.8%	0.0%
3 too far from center	2.4	3.2	2.4	1.6
2 too far from center	4.1	11.3	3.3	1.6
1 too far from center	21.1	21.0	8.9	12.9
0 = "right"	30.9	24.2	21.1	21.0
1 too near the center	21.9	21.0	23.6	22.6
2 too near the center	13.8	11.3	20.3	21.0
3 too near the center	1.6	8.1	12.2	12.9
4 too near the center	3.3	0.0	5.7	4.8
5 too near the center	0.0	0.0	0.0	1.6
6 too near the center	0.0	0.0	1.6	0.0

Some interest attaches to the absolute amount of the errors in recognizing the squares, considered merely from the point of view of errors of memory. The following table shows the absolute amount of the error in millimeters for the subjects examined by each experimenter. The standard was a square 100 millimeters wide. The figures show that the first square (the one estimated on the "medium" board) was systematically underestimated, and that the next (the one picked out on the "small" board) was also underestimated. The underestimation is greater for the "small" than for the "medium" on the part of the women, but the same for the men. These figures conform with statements above, which were derived from a consideration of the number of persons who underestimated, in the "small" set, relative to the "medium" set. The square chosen in the "large" set indicates a considerable *overestimation,* which is comprehensible in terms of the tendency to make a selection toward the center of the set.

A slight difference between the sexes appears here in the fact that the general averages give more underestimation in the "small" set and more overestimation in the "large" set among the women than among the men. Yet it must be observed that the findings of only half the experimenters support this average.

The individual measurements are not finely enough graded to warrant the computation of correlations.

AVERAGE ERROR IN THE RECOGNITION OF A 100-MM. SQUARE

Experimenter	Number women	Medium set	Small set	Large set
A	14	— 2.14	— 4.64	2.50
C	12	2.08	— 4.17	5.00
G	16	— 0.31	— 2.81	6.87
He	11	— 5.81	— 5.47	1.82
Ho	14	— 0.71	— 1.43	2.14
I	13	— 4.23	— 5.38	2.31
J	9	—10.00	1.11	1.67
M	24	— 2.29	— 2.29	3.96
S	10	— 0.50	— 4.50	1.50
All	123	— 2.36	— 3.25	3.33

Experimenter	Number men	Medium set	Small set	Large set
A	6	— 2.50	— 2.50	— 0.83
C	7	— 4.29	— 0.71	— 0.71
G	7	0.00	0.71	9.29
He	9	— 3.33	— 3.33	2.22
Ho	1	— 5.00	—10.00	10.00
I	5	— 4.00	0.00	1.00
J	6	— 1.67	— 0.83	5.00
M	8	— 3.75	— 3.12	2.50
S	13	— 2.31	— 6.52	2.31
All	62	— 2.74	— 2.74	2.74

4. MEMORY FOR PICTURES[16]

The directions for this experiment were as follows:

It is the purpose of this experiment to test the accuracy of your memory for pictures.

Two pictures will be shown to you, one after the other, for a short time. Observe them closely. After you have looked at them questions will be given to you to answer about them.

The two pictures are the ones called "Washington and Sally" and the "Disputed Case." Each was exposed for fifteen seconds. The experiment was so planned that either picture had the first exposure as often as the other. During the first season's work (1912–13) the questions on one picture were delayed for about twenty-five minutes while other experiments were being per-

[16] The pictures used in this experiment are those referred to by Whipple, *Manual of Mental and Physical Tests*, p. 301, edition of 1910.

formed; and meanwhile the subject was given to understand that no further questions were to be asked about the pictures Later, all the questions were asked immediately after the exposure of the second picture.

This experiment proved unsatisfactory, largely because too much was attempted in it. Four questions were asked about each picture. Two of them were perfectly open categorical questions; the other two were misleading questions involving a false dilemma.

QUESTIONS ON "WASHINGTON AND SALLY"

1. How many persons are dancing? Correct answer: Two.
2. Which foot has the gentleman who is dancing advanced, his right or his left foot? Correct answer: His left foot.
3. Is his waistcoat pink or purple? Correct answer: Neither; it is buff.
4. Is the sword belonging to the scabbard he wears lying on a chair or standing against the wall? Correct answer: Neither; it is in the scabbard.

QUESTIONS ON "THE DISPUTED CASE"

1. Of the two persons represented in the picture, tell whether both are sitting, or is one standing? Correct answer: Both sitting.
2. What is the man looking at who faces you? Correct answer: The papers in front of him.
3. What is the other man holding in his hand, an umbrella or a pen? Correct answer: Neither; the hand is empty.
4. Are the books visible in the bookcase bound in yellow or in black? Correct answer: Neither; there are no books visible.

The detailed results do not seem to be worth reproducing. The following figures show the final results obtained by consolidating the answers to all four categorical questions together and for all four suggestive questions together, without regard to the secondary conditions under which the various answers were obtained.

Number subjects	Per cent correct answers	Per cent refusals to answer	Per cent incorrect answers	
74 women	15	46	39	With suggestion
74 women	72	6	23	Without suggestion
59 men	18	43	39	With suggestion
59 men	67	9	24	Without suggestion

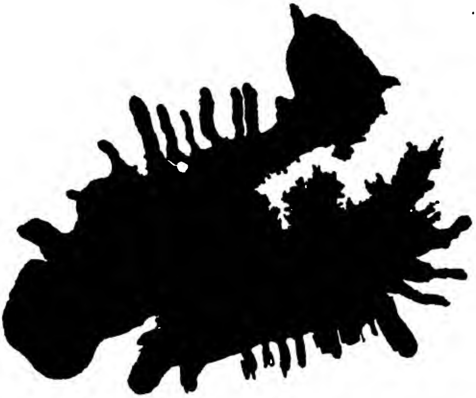
From these aggregate figures it does not appear that there is any difference between the sexes in respect to the inaccuracy of the answers to the categorical questions or in respect to the inaccuracy of the answers under the false dilemma; in the one case 23 or 24 per cent are erroneous, and in the other case 39 per cent are erroneous for both sexes. The only significant sex difference which appears is in the relative number of correct answers and the relative number of cases of refusal to answer. Without suggestion the women give relatively more correct answers than the men and less frequently refuse to give any answer. Under suggestion this relation between the sexes is reversed, the women are then more apt than the men to take refuge in a refusal and less apt than they to give a true statement. So that if we are to say that women are more suggestible it is only in the matter of the relative decrease in the number of correct answers, not in the number of errors.

5. Ink-Blot Test of Imagination[17]

The blots used were from the standard set designed by Whipple. During the first season blot No. 7 was used. The following season No. 12 was substituted because no copy of No. 7 could be found in the laboratory at the time of beginning work, and because it was thought that the use of another blot might bring out some interesting information.

Since completing the suggestion experiments, it has been possible to standardize the two blots by ascertaining the number of ideas which each of them suggests. This was done by issuing copies of the blots to the members of a large college class. Half of the members of the class received one blot and half the other. They were allowed two minutes in which to look at the blot and write down all the ideas which it suggested to them. The results are shown below. The figures show the average number of ideas

[17] A brief review of ink-blot experiments, beginning with their origination by Binet and Henri, *Année Psychologique*, 2, 1895, p. 444, may be found in Whipple, *Manual of Mental and Physical Tests*, p. 430, edition of 1910.



7.

Fig. 17—Blot No. 7.

12.

Fig. 18—Blot No 12.

per person, the number of these which are the names of animals, and the percentage of "animals" among the ideas.

Subjects	Blot	Average number ideas	Average number animals	Percentage of animals
79 women	No. 7	4.94	1.73	35.1%
58 men	No. 7	4.53	1.60	35.4
83 women	No. 12	4.43	1.18	26.6
57 men	No. 12	4.49	1.09	24.2
162 women	Both	4.68	1.45	31.0
115 men	Both	4.51	1.26	27.9
137 persons	No. 7	4.77	1.68	35.2
130 persons	No. 12	4.46	1.14	25.6

From these figures it appears that blot No. 7 is more suggestive, and that it is more apt to suggest animals than No. 12. More ideas are suggested to women than to men, but not by No. 12, and a larger proportion of animals are suggested to women, but not by No. 7.

In the suggestion experiment itself it was desired to find out not only whether the blots suggested more ideas to men than to women, but also whether a covert reference in the directions to "animals" would influence the members of one sex more than the other. The directions employed for this purpose were as follows:

Individuals differ greatly in the fertility of their imagination. It is the aim of this experiment to find out how many things will be suggested to your mind by a senseless ink-blot. This particular blot may make you think of some kind of animal, or of any number of other things. See how many things you can write down in two minutes that the blot might be a picture of.

The data are given in the following table, which is arranged to show the results obtained by the separate experimenters with the different blots.

IDEAS SUGGESTED TO WOMEN

Experimenter	Number subjects	Blot	Ideas per subject	Animals per subject	Percentage of animals
A	19	No. 12	4.1	1.1	27%
C	9	No. 12	5.9	1.0	17
G	18	No. 7	6.2	2.9	46
He	10	No. 7	5.4	2.7	50
I	12	No. 12	5.5	4.2	8
S	11	No. 12	6.7	1.9	27

IDEAS SUGGESTED TO MEN

Experimenter	Number subjects	Blot	Ideas per subject	Animals per subject	Percentage of animals
A	10	No. 12	3.3	0.8	24%
C	6	No. 12	3.5	1.0	29
G	6	No. 7	3.3	1.5	45
He	19	No. 7	5.0	1.6	33
I	6	No. 12	6.2	2.2	35
S	11	No. 12	5.0	1.4	27

The following table gives the data in such a form that they may be compared with the standard figures previously given.

Subjects	Blot	Average number ideas	Average number animals	Percentage of animals
28 women	No. 7	5.9	2.8	48%
25 men	No. 7	4.6	1.6	35
51 women	No. 12	5.3	1.1	21
33 men	No. 12	4.4	1.3	29
79 women	Both	5.53	1.71	30.9
58 men	Both	4.50	1.41	31.4
53 persons	No. 7	5.3	2.2	42
84 persons	No. 12	5.0	1.2	24

These figures agree with those obtained without suggestion in the following respects: Blot No. 7 is more suggestive than No. 12, and it is more apt to suggest animals. More ideas are suggested to women than to men, and in the present case there is no exception for No. 12, though the difference between the sexes is not so great for No. 12 as for No. 7.

With respect to the number of "animals" suggested there is no clear result which can be attributed to the reference to animals in the directions. The proportion of "animals" in blot No. 7 increases considerably for women, but not for men, under the influence of the reference to animals in the directions. Blot No. 12 shows a decrease for women and an increase for men. On the whole, there seems very little ground for believing that the reference to animals in the directions had any effect at all. When all the various figures are combined we find that 31.1 per cent of the ideas were "animals" under the suggestive directions, and that 29.8 per cent were "animals" even without the suggestion. Within these narrow limits no sex difference can be found.

But with regard to the total number of ideas suggested by the ink-blot there is a very distinct sex difference. Five of the six experimenters in the suggestion experiment found that the blot suggested more ideas to women than to men, and the average figures indicate that in two minutes a woman can think of at least one more idea which is suggested by the blot than a man

Frequency of Lists of Different Lengths

The figures show the percentile proportion of the subjects who wrote lists containing 1, 2, 3, or any other number of ideas. There were 241 women and 173 men.

Length	Women	Men
1	4.1	6.5
2	8.6	12.4
3	18.0	15.3
4	18.4	27.0
5	19.2	12.4
6	10.2	10.6
7	9.0	5.3
8	3.3	5.9
9	3.7	1.8
10	2.0	1.8
11	0.8	0.6
12	1.6	0.0
13	0.8	0.6
18	0.4	0.0

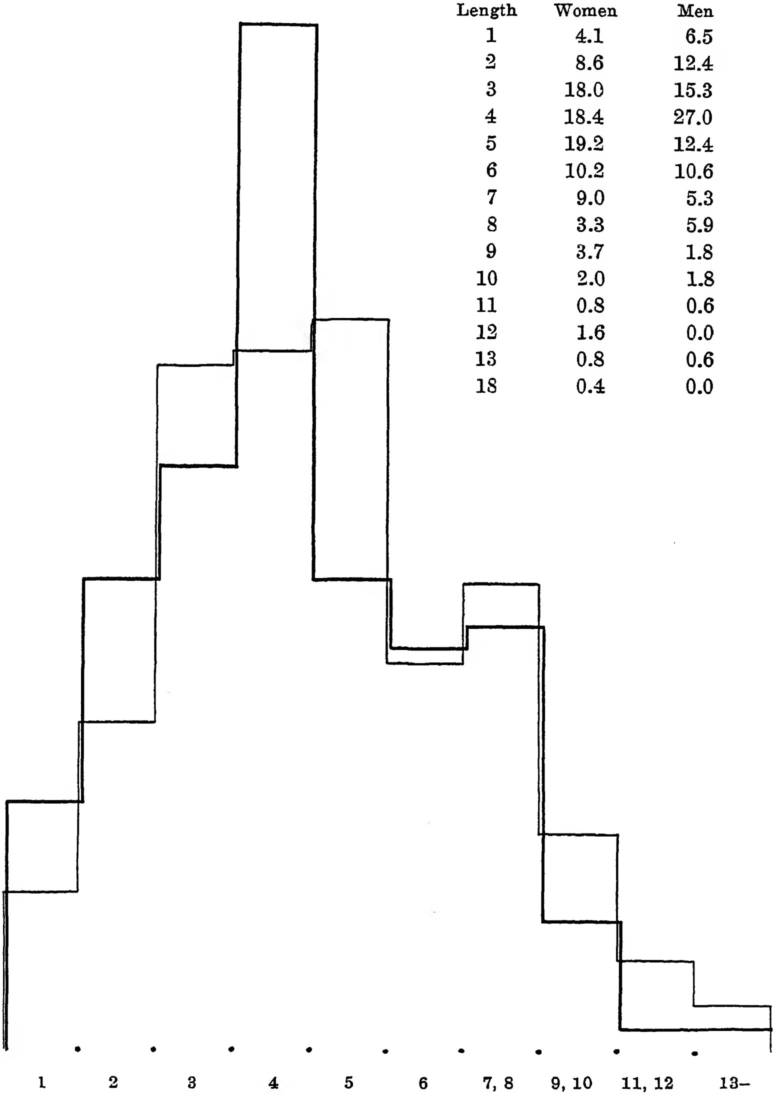


Fig. 19—Ink-blot. Light line, women; dark line, men.

can. The subsequent figures from the class experiment confirm the nature of this sex difference, but make it appear much smaller. An analysis of the data according to the number of persons who got a certain number of ideas is presented for both of the experiments together in the accompanying table and graph.

The difference between the sexes seems to be due in part to the fact that more men give very short lists (one or two words), and that more women give very long lists, but the chief difference is that the men have a distinct mode at a list of four words, while the mode for women is pushed over to a list of five words. There is a difference between the ordinary or typical individuals of the two sexes which is independent of the work of eccentric individuals.

Correlations have been calculated between the rankings in this test and in five other tests. The data are presented in the following table for each of five experimenters separately. The fact that blot No. 7 was used by two experimenters and blot No. 12 by the other three experimenters precludes the computation of correlations for the whole group of persons. Of the

Correlations Between Suggestibility in the Test With Ink-Blots and Suggestibility in Five Other Experiments

Women

Experimenter	Blot	Number subjects	Touch	Size	Motion	Lines	Weights
A	No. 12	19	.24	.00	.19	—.38	.25
G	No. 7	19	.16	.27	—.13	.20	.35
He	No. 7	10	.81	.05	.47	—.03	.10
I	No. 12	12	.22	.22	—.04	.09	.31
S	No. 12	11	.46	—.04	—.19	.52	.31

Men

Experimenter	Blot	Number subjects	Touch	Size	Motion	Lines	Weights
A	No. 12	10	.08	.53	.44	.23	.41
G	No. 7	6	.60	.71	.26	.31	—.15
He	No. 7	19	—.08	—.09	—.19	—.20	—.02
I	No. 12	7	.62	.23	—.02	—.05	—.09
S	No. 12	11	.25	—.16	.25	.30	—.11

twenty-five coefficients which have been calculated, eighteen are positive for the women and fourteen for the men. The correlation with *Touch* is the only one which is fairly consistently positive for both men and women. So far as the data go, there is evidence of a general tendency toward a positive correlation between suggestibility in this test and suggestibility in other tests.

By way of summing up it may be said that:

1. Women are more suggestible than men so far as they are tested by the total number of ideas suggested by the ink-blot.

2. There are positive correlations with other tests.

3. Contrary to the general rule, the correlations are closer for the women than for the men.

6. Summary for the Five Tests Involving Memory, Recognition, or Imagination

So far as sex differences are discernible in these tests, the indications are that women are more suggestible than men. The difference between the sexes is clear in *Recognition of Form* (checkerboard) and *Position* (letters) and in the *Ink-blot* test, less clear in *Recognition of Size*, not clear in *Memory for Pictures*.

All of the experiments of this group fall very far short of the ideal. In three of them a comparatively large proportion of the subjects remain entirely unaffected by the suggestion: *Form*, 22 to 37 per cent; *Position*, 40 per cent; *Size*, 21 to 31 per cent. No graded index of suggestibility is afforded by any of them save the *Ink-blot*, and consequently it is not possible to make accurate measurements of individual differences. This fact prevents the calculation of coefficients of correlation for these tests.

VI

GENERAL INTRODUCTION TO THE REMAINING EXPERIMENTS

All of the experiments which remain to be described follow a radically different method from that of those which have been described so far. Moreover, very few persons took part in these later experiments who had been subjects in the earlier ones. For these reasons it is not possible to make comparisons of individual records between what follows and what has gone before.

All but one of the tests now to be described were performed at a single sitting. This sitting was preceded, however, by another sitting at which records were made without any suggestions. The preliminary records obtained at the first sitting were used as standards by which to measure the effect of the suggestions which were given at the second sitting. The interval between the two sittings was usually three weeks. Proper enquiries were made to avoid the risk of including the records of any persons who might be in the possession of improper information at either test.

All of these tests involved some variation of a single suggestion which was repeated in the various tests in a form determined by the special conditions of that particular test. This suggestion had the general form of an assertion that "most persons do so and so"; for example, "most persons overestimate the weight of the jug." It so happens, of course, that such a statement is generally either true or false, and in order to compensate, as far as possible, for this difficulty, two opposite forms of the suggestion were employed in each experiment. The second form (which will be referred to as B) was the contrary of the first form (A); thus if the first said "most persons *overestimate,*" the second form said "most persons *underestimate.*" When one subject had been given the suggestion in form A, the

next subject of the same sex was given the suggestion in form B, so that in the end about half of the men and half of the women had received the suggestion in one form and the other half of each sex had received the suggestion in the other form.

The suggestions were given, as before, in a sheet of typewritten directions, but with a material difference. The subject had first been through the test without suggestion and when he came for the second sitting the suggestion was *added to* the directions which he had had when he first performed the experiment without suggestion. As an introduction to the suggestive statements there was also a preliminary statement which read as follows:

GENERAL SUPPLEMENTARY DIRECTIONS

To what extent can one's judgment be helped by knowing the results obtained by a number of other people? These experiments are exactly the same as those you took part in before, but in every case the directions give you some information about the judgments which other people have made. These statements are written in red. You are asked to pay especial attention to these statements in each case. It is the purpose of this part of the experiment to discover how much such statements will help you.

Each set of specific directions for a test was presented on a separate sheet of the little booklet of directions, and immediately after the directions which had been given at the first sitting appeared the word "Note" and the statement of the suggestion, printed in red ink. What was there printed in red will appear in italics in the following pages.

The experimenter was expected to see that the subject read the preliminary statement before he began work, and that he read each suggestive statement before he began upon the test in question. But, unfortunately, it can not be assumed that all of the subjects gave the same amount of attention to the preliminary statement, or that they gave it the same interpretation; and there is little ground for supposing that with different experimenters the suggestive notes exerted a uniform influence over different subjects. This mode of presenting the suggestion is not as satisfactory as the method adopted in the earlier experiments, in which the suggestion was inseparably incorporated in

the body of the directions and in the manipulation of the experiment itself. Yet this more open form of suggestion, as employed in the experiments which are about to be described, is not without its advantages.

We shall be particularly interested in discovering whether the individual and sex differences which have emerged rather clearly from the experiments in which the suggestion was surreptitious will still make themselves felt when the suggestion is presented as a separate statement and in such a form that the subject can not fail to be aware of it as distinct element added to an experiment which was already complete in itself.

Because of the division of the subjects for the two sets of directions there are not enough subjects in any one group who were examined by the same experimenter to warrant the presentation of data for the separate experimenters. There were twenty women and twenty-four men who received the suggestions in the "A" form and twenty-one women and nineteen men who received them in the "B" form. The subjects were about evenly distributed among five experimenters.

The correlations for suggestibility in the different tests of this division have been calculated for men and women separately and for the A and B forms of the suggestion separately, so that there are four groups for which the correlations have been calculated for each pair of tests. But in discussing the results it will frequently prove convenient to overlook the division into A and B, and in that event the expression "correlation for men" or "correlation for women" will be used to designate the average of the two coefficients, that for the A group and that for the B group.

VII

TWO EXPERIMENTS DEALING WITH THE EFFECT OF SUGGESTION UPON NORMAL ILLUSIONS

1. The Size-Weight Illusion; 2. The Müller-Lyer Illusion

These two experiments are practically identical in point of method. At the first sitting the subject was allowed to make an adjustment, to suit himself, in the light of whatever he might know about the illusions. At the second sitting he made a fresh adjustment in the face of a positive statement appended to the directions. The difference between these two adjustments is taken as the measure of suggestibility.

1. The Size-Weight Illusion

The following directions, containing no suggestion, were handed to the subjects at the first sitting:

ESTIMATION OF WEIGHTS

You will be shown a set of black weights which have been arranged in order from lightest to heaviest. Lift all of the weights to see how heavy they are, then place the large weight between the two which seem to you the nearest equal to it in actual weight, without regard to size. Do the same with the small weight.

The set of cylindrical black wooden weights, 35 mm. in diameter, and ranging from 5 gm. to 100 gm. in weight, were arranged in order in a row about 15 cm. apart on a table. The large weight (82 mm. in diameter) and the small weight (22 mm. in diameter) were placed at their respective ends of the set and the subjects did not compare them directly with each other.

The one set of suggestive statements (A) read: *Note.—Most people judge the large weight to be much lighter than it really is, but judge the small weight quite accurately.*

The other statement (B) said: *Note.—Most people judge the small weight to be much heavier than it really is, but judge the large weight quite accurately.*

The effectiveness of the suggestion is measured on the basis of the subject's performance at the first sitting, when no suggestion was given. The effect of the suggestion is regarded as positive in so far as the subject tends to correct what is represented to him as the common mistake. The amount of the influence of the suggestion has been measured by the decrease in the amount of the illusion in that part of the illusion to which the suggestive statement applies. In the A directions the suggestion applies only to the estimation of the large weight, and in the B directions only to the estimation of the small weight. In both cases, however, the positive effect of the suggestion is to reduce the amount of the illusion, and the amount of this reduction has been taken as the index of suggestibility.

It might reasonably be thought, however, that a second test would show a smaller error even without the suggestion. In this connection it may be observed that the suggestion does not apply directly to the estimation of the small weight in the A group nor to the estimation of the large weight in the B group. In those cases the second estimate is only slightly more accurate (less illusion) than the first estimate. But when the suggestion does apply (to the large weight for the A group and the small weight for the B group) the second estimate is much better than the first. The figures given below are the amount of the average error, that is, the average amount of the illusion, in grams, for the large weight and for the small weight, in the first test (always without suggestion), and in the second test (partly with and partly without suggestion, depending on the wording of the statement).

	A Group		B Group	
	Large weight	Small weight	Large weight	Small weight
First test, no suggestion	20.8	16.6	22.0	16.5
Second test, no suggestion	......	15.3	20.7	......
Second test, with suggestion	15.0	......	......	8.0

There can be no doubt that the suggestion operates normally to reduce very greatly the amount of the usual illusion. This

can be made clearer by considering the results without regard to whether the error occurred on the small or large weight. Then the average error of the first trial is 19 grams, the average error of the second trial *without* suggestion is 18 grams, and the average error of the second trial *with* suggestion is only 11.5 grams.

The fundamental facts regarding sex differences in this experiment are contained in the following table. The figures show the average amount of the illusion, in grams, under the various conditions mentioned.

		A Group			B Group		
Subjects	Weight	First test	Second test		First test	Second test	
20 women	Large	23.8	16.3	(with sug.)	24.9	22.7	(no sug.)
24 men	Large	18.4	14.0	(with sug.)	18.8	18.6	(no sug.)
21 women	Small	18.8	17.0	(no sug.)	17.5	11.8	(with sug.)
19 men	Small	14.8	14.0	(no sug.)	15.4	5.9	(with sug.)

A simple analysis of these figures shows that the average amount of the effect of the suggestion in reducing the size of the illusion, in grams, is as follows:

	A Group	B Group	A and B
Women	7.5	5.7	6.6
Men	4.4	9.5	6.6

From this it appears that there is no sex difference for the entire experiment, taken as a whole. The women are more suggestible in the A portion and the men more suggestible in the B portion, but when the data for both portions are combined it appears that the average influence of the suggestion is exactly the same for both sexes.

But, while the crude data for this experiment give no consistent sex difference in suggestibility, there are certain corrections which ought, probably, to be considered before arriving at a conclusion. In the first place, the women are more apt than men to reduce the amount of the illusion in the second trial in that part of the work in which the directions assert that "most per-

sons judge quite accurately.'' The extent of this tendency is revealed in the following figures. These figures show the average amount by which the illusion is reduced in the second test when the suggestion does not apply to the weight considered.

	A Group	B Group	A and B
Women	1.8	2.2	2.0
Men	0.8	0.2	0.5

It is probably just that the amount of the reduction in the illusion which has been attributed to the suggestion should be diminished by the amount of reduction which would occur in the second trial even without the suggestion. If this is done, we get the following figures to show the net effect of the suggestion in reducing the illusion.

	Large weight	Small weight	Both
Women, decrease second trial with suggestion	7.5	5.7	6.6
Women, decrease second trial without suggestion	1.8	2.2	2.0
Women, net decrease due to suggestion	*5.7*	*3.5*	*4.6*
Men, decrease second trial with suggestion	4.4	9.5	6.6
Men, decrease second trial without suggestion	0.8	0.2	0.5
Men, net decrease due to suggestion	*3.6*	*9.3*	*6.1*

This treatment of the data makes it appear that the men are more suggestible, and there is still another correction to be made which tends to strengthen this inference. Reference to the fundamental table on page 373 shows that the illusion itself, without regard to suggestion, is much stronger for the women than for the men. When the figures are combined we obtain the following averages for the first test, before any suggestion had been given, for the absolute amount of the illusion in grams:

	Large weight	Small weight	Average
Women	24.4	18.4	21.4
Men	18.6	15.1	17.0

Now if, instead of regarding the effect of the suggestion in the light of an absolute amount of weight (so many grams), we regard it as a proportion of the original amount of the illusion, we obtain the following figures. These figures show the effect

of the suggestion in reducing the amount of the illusion, expressed in per cent of the original amount of the illusion.

	A Set Large weight	B Set Small weight	Both
Women	23%	19%	22%
Men	19	62	36

Or if, instead of the net (corrected) amount of the reduction, we take the uncorrected, crude, amount of it:

	A Set Large weight	B Set Small weight	Both
Women	31%	31%	31%
Men	24	63	39

The result of these corrections makes it appear that men are more suggestible than women under the B form of the suggestion, and when the two forms are considered together, but not under the A form.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who were induced by the suggestion in the second trial to reduce the amount of the illusion by the number of grams indicated. The number of grams given as the amount of the reduction of the illusion is the difference between the estimate made at the first trial, when there was no suggestion, and the estimate made at the second trial, under the influence of the suggestion. A negative figure means that the amount of the illusion was increased instead of being decreased at the second trial in spite of the admonition of the suggestive statement.

Full Table

Amount of reduction	Women	Men
—20 g. and less	4.9%	0.0%
—15 g.	0.0	2.3
—10 g.	0.0	11.6
— 5 g.	7.3	16.3
0 g.	17.1	11.6
5 g.	22.0	11.6
10 g.	26.8	11.6
15 g.	9.7	18.6
20 g.	2.4	7.0
25 g.	4.9	2.3
30 g.	2.4	2.3
35 g.	0.0	2.3
40 g.	2.4	2.3

Condensed Table

Amount of reduction	Women	Men
—5 g. and less	12%	30%
0 or negative	29	42
5 or 10 g.	49	23
15 g. or over	22	34
20 g. or over	12	16

The distribution of the degrees of suggestibility (see the graphs, fig. 20) shows that the men are more apt to prove strongly suggestible or else to react in a strongly negative manner. The women tend to group more closely about a mode in the middle on the smaller degrees of suggestibility.

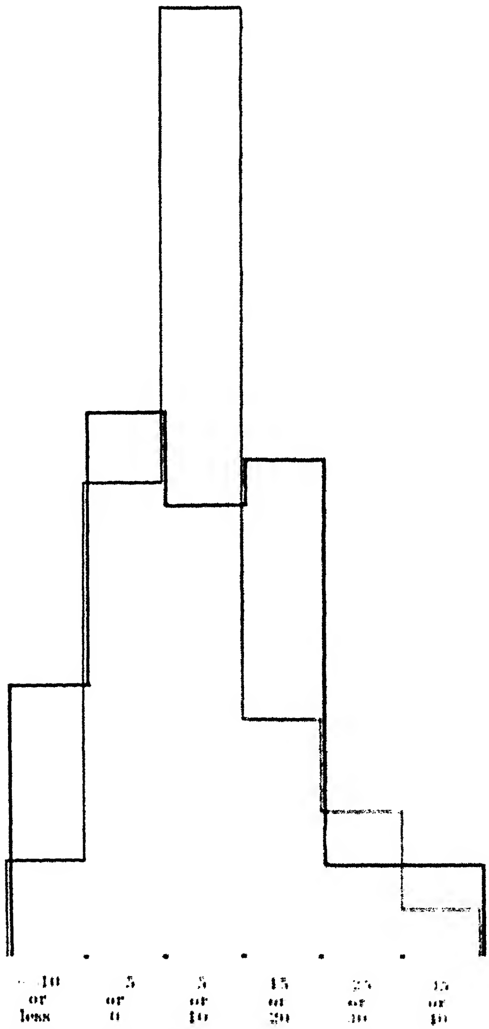


Fig. 20—Size-Weight Illusion. Light line, women; dark line, men.

The correlations between the rankings in this test and the rankings in other tests bear indications of a sex difference which has been noted frequently before, namely, that the correlations are more apt to be distinctly positive for the men than for the women. There are twelve correlations to be considered for each sex, for there are two correlations with each of the other six tests with which this one is correlated because of the division of the data on the basis of the A and B directions. Of the twelve for the women, six are negative, but nine of the twelve for men are positive.

There is no particular test with which this one is closely related if we judge by the indices of correlation. The other illusion test (the Müller-Lyer, to be described in the next section), which has many points of outward resemblance with this test, does not show a high or consistently positive correlation with it.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE EXPERIMENT WITH THE SIZE-WEIGHT ILLUSION AND SUGGESTIBILITY IN SIX OTHER TESTS

	Women A	Women B	Men A	Men B
Müller-Lyer	.05	.21	—.11	.09
Distance	—.09	—.28	.33	.29
Weight	.07	—.29	.38	—.42
Rectangle	—.14	—.26	.22	.53
Triangle	—.32	.33	.12	.38
Cross	.02	.05	.28	—.15

The results of this experiment may be summarized as follows:

1. Men are probably subject to the suggestion to a greater extent than women, although more men than women resist it.

2. There is a positive correlation between this test and a majority of the other tests for men, but not for women.

2. MÜLLER-LYER ILLUSION

The directions which were handed to the subject at the first sitting were as follows:

ESTIMATION OF LENGTH OF LINES

You will be shown an example of the visual illusion called the Müller-Lyer illusion. It is so arranged that one arrowhead is adjustable in each figure. You are asked to adjust figure A (←→) and figure B (>—<) so

that the line between the arrowheads appears to be equal to the standard line, M, in both cases.

The drawings were placed in a frame on a table so that the subject adjusted them while standing up. The drawings were arranged in the manner indicated in the figure below. The standard line between the two forms of the illusion was 20 cm. long. The right-hand angle of each illusion figure was drawn on a separate card which could be moved back and forth in a track by the subject until he got it to suit him. The lines themselves did not move and the ends of them did not tally with one another.

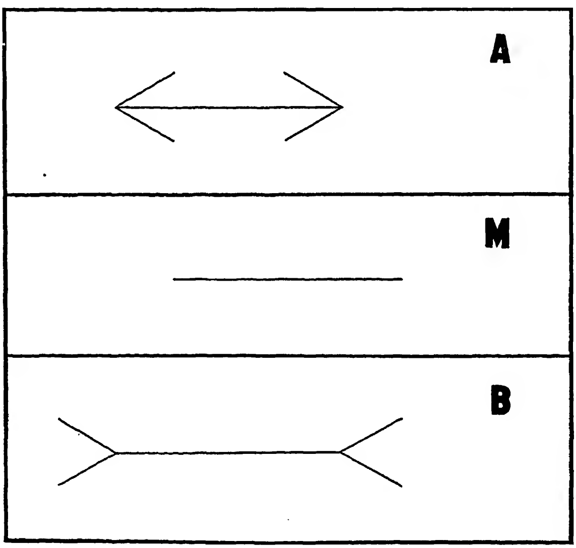


Fig. 21

The supplementary statement containing the suggestion read as follows for the A set: *Note.—Most persons make the line in figure A* (⟵⟶) *much too long, but judge the line in figure B* (>—<) *quite accurately.*

The other set of directions (B) read: *Note.—Most persons make the line in figure B* (>—<) *much too short, but judge the line in figure A* (⟵⟶) *quite accurately.*

The influence of the suggestion was measured, just as in the last experiment (*Size-Weight Illusion*), by taking the difference between the first adjustment, made without any suggestion, and the adjustment made at the second sitting, when there was a suggestion. It may be assumed, for the purpose of obtaining an index of suggestibility, that the second adjustment would be the same as the first, except for the effect of the suggestion which accompanies the second directions. In what sense this assumption is correct may be seen from the following figures. These figures show the actual amount of the illusion, for each of the two figures, in the first trial when there is no suggestion, and in the second trial, when there is suggestion or is none, according to the wording of the directions. The numbers indicate millimeters.

	A Group		B Group	
	Arrow-head figure	Feather-head figure	Arrow-head figure	Feather-head figure
First test, no suggestion	27	9	28	11
Second test, no suggestion	—	17	31	—
Second test, with suggestion	19	—	—	4

The effect of the suggestion is to reduce the amount of the illusion. The above figures show that the illusion is not reduced, but is considerably increased, in the second trial unless the suggestion is present. A combination of these numbers shows that the illusion amounts to 19 mm. in the first trial and to 24 mm. in the second trial when no suggestion is made; but when there is a suggestion it amounts to only 12 mm.

The essential facts regarding sex differences in this experiment are to be found in the following table. The numbers show

		A Group		B Group	
Subjects	Illusion figure	First test	Second test	First test	Second test
20 women	Arrow	36	25 (with sug.)	28	34 (no sug.)
24 men	Arrow	19	13 (with sug.)	29	28 (no sug.)
21 women	Feather	15	20 (no sug.)	12	5 (with sug.)
19 men	Feather	5	14 (no sug.)	10	4 (with sug.)

the average amount of the illusion, that is, the difference between the length of the standard line and the length of the illusion figure as adjusted by the subject. The amounts are given in millimeters.

A simple analysis of these figures shows that the average amount of the effect of the suggestion in reducing the size of the illusion is as follows, in millimeters:

	A Group	B Group	A and B
Women	11	7	9
Men	6	6	6

These figures indicate that the women are influenced by the suggestion to a greater extent than the men. But there are certain corrections which should probably be considered before a final inference is drawn. There is a difference, as has been noted, between the two trials when no suggestion is given, and it is probably legitimate to add the amount of this difference to the crude measure of the suggestion. The average amount of the increase of the illusion in the second trial in that part of the work in which the suggestive statement merely asserts that most persons "judge quite accurately" is as follows:

	A Group	B Group	A and B
Women	6	5	5.5
Men	—1	9	4

When these amounts are added to the crude measure of the influence of the suggestion the following figures result:

	Arrow	Feather	Both
Women, decrease second trial with suggestion	11	7	9
Women, increase second trial without suggestion	6	5	5.5
Women, net change due to suggestion	*17*	*12*	*15*
Men, decrease second trial with suggestion	6	6	6
Men, increase second trial without suggestion	—1	9	4
Men, net change due to suggestion	*5*	*15*	*10*

From this it appears that the women are more suggestible for the arrow figure (suggestion A), but not for the feather

figure, and that they are more suggestible if results are combined for the two figures. But we still have to consider the fact that the illusion itself, without other suggestion, is more effective with the women than with the men. This may be seen from the following figures, which show the amount of the illusion, in millimeters, for the first trial, before any suggestions had been offered.

	Arrow	Feather	Both
Women	32	14	23
Men	24	8	17

Now, if we regard the effect of the suggestion in reducing the illusion, not as an absolute number of millimeters but as a fraction of the amount of the illusion itself, we obtain the following figures. These figures show the effect of the suggestion in reducing the illusion expressed as a percent of the original amount of the illusion.

	A Group (Arrow)	B Group (Feather)	Both
Women	53%	86%	65%
Men	21	187	59

Or, if we base the percent upon the uncorrected, crude, amount of the effect of the suggestion in reducing the illusion:

	A Group (Arrow)	B Group (Feather)	Both
Women	34%	50%	39%
Men	25	75	35

From any of the points of view which have been proposed the women appear more suggestible in the case of the arrow figure, and in the average for the two figures, but not for the feather figure.

An inspection of the distribution of the different degrees of suggestibility which is shown in the graph (fig. 22) confirms the evidence from the average figures that the women are more suggestible. Some 35 per cent of the men show no effect, or a

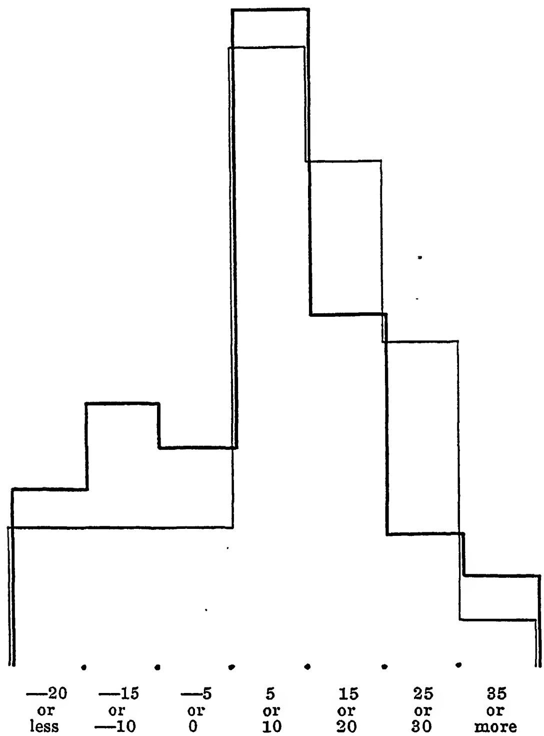


Fig. 22—Müller-Lyer Illusion. Light line, women; dark line, men.

negative effect, of the suggestion, while only 22 per cent of the women resist the suggestion in this way. About the same proportion of men as women show a small positive influence (5 or 10 mm.), but a larger proportion of the women show a large positive effect. Of the women, 20 per cent are influenced to an extent greater than 25 mm., while only 12 per cent of the men are influenced to that extent. It may be of interest to note that for these last-mentioned women, one-fifth of all the women, the influence of the suggestion (25 mm. or more) is actually greater than the average amount, for all the women, of the Müller-Lyer illusion itself.

Frequency of Different Degrees of Suggestibility

The figures show the percentile proportion of the subjects who were induced by the suggestion to reduce the amount of the illusion by a stated number of millimeters. The number of millimeters given as the amount of the reduction of the illusion is the difference between the adjustment made at the first trial, when there was no suggestion, and the adjustment made at the second trial, under the influence of the suggestion. A negative figure means that the amount of the illusion was increased instead of being decreased at the second trial in spite of the admonition of the suggestive statement.

Full Table

Amount of reduction	Women	Men
—30 mm. or less	4.9%	2.3%
—25 mm.	2.4	0.0
—20 mm.	0.0	7.0
—15 mm.	4.9	4.7
—10 mm.	2.4	9.3
— 5 mm.	7.3	2.3
0 mm.	0.0	9.3
5 mm.	12.2	13.9
10 mm.	19.5	20.9
15 mm.	21.9	11.6
20 mm.	4.9	7.0
25 mm.	7.3	2.3
30 mm.	9.8	4.7
35 mm. or more	2.4	4.7

Condensed Table

Amount of reduction	Women	Men
0 or negative	22%	35%
5 or 10 mm.	32	35
15 mm. or over	46	30
20 mm. or over	24	19
25 mm. or over	20	12

The correlation of this test is not high with any of the other six, except perhaps *Triangle,* and the latter is a test which has comparatively high correlations with nearly all of the others. Negative correlations are almost as frequent as positive ones in the present case.

Correlations Between Suggestibility in the Test With the Müller-Lyer Illusion and Suggestibility in Six Other Tests

	Women A	Women B	Men A	Men B
Size-Weight	.05	.21	—.11	.09
Distance	.00	.24	—.01	.12
Weight	—.30	—.31	—.14	—.07
Rectangle	—.04	.02	—.24	—.15
Triangle	.16	.39	.21	.20
Cross	—.13	.34	.06	.21

In conclusion it may be said for this experiment that:

1. Women are probably more suggestible than men.
2. Positive correlations with other tests are only slightly more frequent than negative ones.
3. Contrary to the general rule, more positive correlations appear with women than with men.

3. Conclusions Concerning the Two Experiments With Illusions

Both of these experiments are based on the assumption that most persons will take advantage of a hint which is given them concerning the nature of the mistakes made by others and, by implication, by themselves as well, and that the second estimate will show a tendency to correct what is supposed to be the common mistake. As a matter of fact, most persons do act in this way. In the *Size-Weight Illusion* there is a tendency, it is true, to reduce the illusion even for that part of the work in which the directions assert that "most persons judge quite accurately," but the tendency to reduce the illusion is much stronger when the directions suggest such a reduction; 71 per cent of the women and 58 per cent of the men respond in the way that was expected. With the *Müller-Lyer Illusion* the amount of the illusion is increased in the absence of a hint, so that the reduction of it under the influence of the suggestion is not open to any question; in that case 78 per cent of the women and 65 per cent of the men respond in the way that was expected. Both experiments may be regarded as successful in so far as they obtain a response from a large proportion of the subjects. Unfortunately they leave a good deal to be desired when it comes to the measurement of the responses which are obtained.

The sex differences which develop in these experiments are not entirely clear. In both of them a larger proportion of the women than of the men follow the direction of the hint which is given and react as it was expected that "suggestible" persons would react. But the measurement of the magnitude of the

influence of the suggestion reveals contradictions. Men are suggestible to a greater extent in the *Size-Weight Illusion* on the whole, but not in one part of it; and women are more suggestible in the *Müller-Lyer Illusion,* but not in one part of it.

In connection with the sex difference, it may be of interest to note that the extent of the illusions themselves, when no additional suggestions are made, is considerably greater among the women than among the men.

Neither of these tests correlates very well with the other tests of this division. Furthermore, they do not correlate well with each other. In spite of the close resemblance of the two in the manner of their administration and in the method of scoring the results, it appears from the correlations that a person who yields readily to one of them has nearly as good a chance as anyone else of escaping from the snares of the other.

VIII

TWO EXPERIMENTS DEALING WITH THE EFFECT OF SUGGESTION UPON THE ESTIMATION OF MAGNITUDE

1. Estimation of Distance; 2. Estimation of Weight

These two experiments are very much alike. At the first sitting the subject was asked to make an estimate of a weight, and of the length of a string, and at the second sitting he was again asked for an estimate of the same weight and distance. The difference between the two estimates is assumed to be due to the influence of the suggestion which was given with the directions for the second test. Unfortunately there was no way of obtaining a direct measure of the amount of change which would have occurred between the two estimates if there had been no suggestion, but a comparison of the results of the two

suggestions, the influence of which was in opposite directions, partly obviates this difficulty.

A special difficulty, which was encountered to some extent in all of the experiments of this entire division, but which becomes particularly obvious in these experiments, is that persons whose memory is good will recollect at the second sitting the judgments which they made at the first sitting. The fact that such people repeat at the second test the estimate made at the first sitting is not always attributable to lack of suggestibility, but may be due to greater tenacity of memory. In the estimation of distance, 18 per cent of the subjects gave exactly the same estimate in the second test that they had given in the first test. In the estimation of weight, 17 per cent gave exactly the same estimate. Only three persons among those who gave the same estimate for the weight also gave the same estimate for the distance.

1. Estimation of Distance

The original directions, containing no suggestion, were as follows:

ESTIMATION OF DISTANCE

You will be shown a white cord suspended from the skylight. You are asked to estimate the distance on this cord from the marker near the top to the marker near the bottom. Do not try to estimate by comparison with parts of the building, or anything of that kind, but only by looking directly at the cord itself. The slat nailed to the railing gives the length of one foot to aid you in making the estimate. Make the estimate as accurately as you can in feet and inches.

A white cord 2 mm. thick was hung from the skylight down into the stairwell with one marker (a spool) at a distance of about fifteen feet above the floor and in front of the subject and the other about four feet below his feet. Under the circumstances it was extremely hard to find any known distance with which to compare the length indicated on the string. The one foot standard was nailed to the railing of the well directly in front of the subject.

The accuracy with which the distance is estimated is a matter of some interest quite apart from any effect of suggestion. The distance was overestimated by 58 per cent of the men and by 63 per cent of the women. The average overestimation among the men is 2.2 feet, and among the women 1.9 feet. The following table shows the actual number of persons of either sex whose estimate departed from the true distance of 19 feet by the number of feet stated.

Estimate	Women	Men	Actual estimate
5 feet or more too short	2	0	
4 feet too short	3	0	15 ft.
3 feet too short	3	6	
2 feet too short	3	2	
1 foot too short	3	7	
Exactly right	1	3	19
1 foot too long	8	4	20
2 feet too long	2	2	
3 feet too long	6	5	
4 feet too long	1	2	
5 feet too long	2	4	
6 feet too long	3	3	25
7 feet too long	0	1	
8 feet too long	1	0	
9 feet too long	1	0	
11 feet too long	2	3	30
13 feet too long	0	1	
	41	43	

A somewhat uneven distribution of the judgments arises from the tendency to make the estimate in a round number of feet, 20, 25, or 30 feet. The most common estimate for both men and women is not far from the true distance. The cases scatter out much more over the estimates which are too great than over those which are too small. This corresponds to a feeling which the subjects often expressed by saying "not less than 18 feet," "not less than 20 feet," etc. Apparently there is a strong tendency to fix a lower limit below which an estimate is very improbable, while the upper limit is indefinite. The feeling is that the dis-

tance is surely not less than a certain amount but may be a great deal more. This point will be reverted to in discussing the experiment upon the *Estimate of Weight,* which comes next.

It may be noted now that one of the suggestive statements (B, given below) was in accord with the general tendency to overestimate the distance, for it said that most people make the estimate too small, and that, of course, encourages the tendency to make it too large. This suggestion, which is in accord with the spontaneous tendency of the subjects, proves to be effective with more persons and to a greater extent than the other suggestion.

The suggestive note appended to one set of directions (A) for the second sitting said: *Note.—Most persons judge the distance to be longer than it really is.* The other (B) set said "shorter" instead of "longer".

The data of the following table show that the second estimate was really influenced, in the average, by the suggestive statement. The figures show the average estimate of the distance, in feet, in the first test, when there was no suggestion, and in the second test, when there was a suggestion. The mean variation of the average estimate is also shown.

	Suggestion A to make shorter		Suggestion B to make longer	
	Feet	M.V.	Feet	M.V.
Women, first test, no suggestion	21.2	3.4	20.6	3.4
Women, second test, with suggestion	20.0	3.1	23.0	3.9
Women, effect of suggestion	*1.2*	......	*2.4*	......
Men, first test, no suggestion	21.0	3.4	21.5	3.6
Men, second test, with suggestion	20.7	3.0	23.0	3.6
Men, effect of suggestion	*0.3*	......	*1.5*	......

The average of the second estimate differs from the average of the first estimate in the direction of the suggestion for both men and women and for both forms of the suggestion.

Yet, in spite of the convincing consistency of the averages, the following figures show that nearly half of the individuals

resisted the suggestion or reacted in the opposite direction. The figures are the proportion of all the subjects (in per cent) who resisted the suggestion.

	Sugges-tion A	Sugges-tion B	Both
Women	45%	33%	39%
Men	67	42	56
Both	57	38	48

The figures which have been given, together with the graph showing the distribution of degrees of suggestibility, indicate a decided difference between the sexes. The average amount of the influence of the suggestion is greater for women than for men, and a larger proportion of the women yield to the suggestion. Moreover, a greater proportion of the women prove

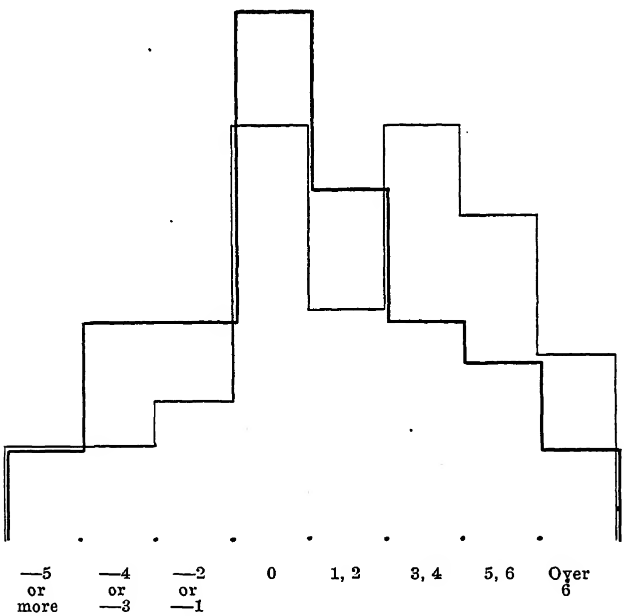


Fig. 23—Estimation of Distance. Light line, women; dark line, men.

suggestible to a comparatively large extent, as may be seen from the graph (fig. 23). Of the women, 27 per cent change their estimate in the direction of the suggestion by five feet or more, while only 14 per cent of the men are influenced to so great an extent.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who changed their second estimate from their first by the number of feet indicated. A negative number of feet means a change contrary to the suggestion.

Change in feet	Women	Men
—5 or more feet	4.9	4.7
—3 or —4 feet	4.9	11.6
—1 or —2 feet	7.3	11.6
0 foot	22.0	27.9
1 or 2 feet	12.2	18.6
3 or 4 feet	22.0	11.6
5 or 6 feet	17.1	9.3
Over 6 feet	9.7	4.7

Special note must be made, in interpreting the table above, of the fact that the figures entered opposite zero include all the cases in which the second estimate was less than one foot different from the first estimate. A good many changes (6 per cent of all the cases) of only a few inches were reported, so that the figures given opposite zero do not indicate the exact number of persons whose second estimate was precisely the same as their first. The figures given probably include some persons who remembered their first judgment and stuck to it, and also some who remembered their first judgment and compromised with the suggestion by making a change of only a few inches.

Of the 24 separate coefficients of correlation, 14 are positive. The correlations with the closely analogous *Estimation of Weight* (to be described immediately) are distinctly negative in three cases out of four. The only high correlations are with *Rectangle,* and less clearly with *Triangle* and *Cross,* tests which are apt to have higher correlations on their own account.

Correlations Between Suggestibility in the Estimation of a Distance and Suggestibility in Six Other Tests

	Women A	Women B	Men A	Men B
Size-Weight	—.09	—.28	.33	.29
Müller-Lyer	.00	.24	—.01	.12
Weight	—.35	—.16	.25	—.30
Rectangle	.47	—.03	.24	.31
Triangle	.03	.06	—.02	.64
Cross	.16	.31	.45	—.29

The conclusions from this experiment are:

1. Women are decidedly more suggestible than men.

2. There is a majority of positive correlations between this test and other tests.

3. The correlations are more distinctly positive for men than for women.

2. Estimation of Weight

This experiment is very similar to the one just described. The first (non-suggestive) directions were:

ESTIMATION OF WEIGHT

You will be given a jug of water and a one-pound weight. You are asked to estimate the weight of the jug of water by lifting it. Make the estimate as accurately as you can in pounds and fractions of a pound.

Enough water had been put into a corked two-gallon demijohn to make it weigh 17 pounds. An ordinary one-pound iron disc weight, such as is used with balances, was also given to the subject. The subject could take the weight in one hand while he hefted the jug with the other.

The estimates of the weight of the jug of water were many of them very inaccurate. There was a strong tendency among both men and women to underestimate the weight; 71 per cent of the women and 72 per cent of the men underestimated the weight by a pound or more. The average underestimation among the men was 4.1 pounds and among the women 3.3 pounds. The following figures show the actual number of persons of

either sex who made an estimate departing from the actual weight of 17 pounds by the number of pounds indicated.

Estimate	Women	Men	Actual estimate
More than 12 pounds too light	1	1	
12 pounds too light	3	3	5 lbs.
11 pounds too light	2	2	
10 pounds too light	0	1	
9 pounds too light	1	2	
8 pounds too light	2	2	
7 pounds too light	6	7	10
6 pounds too light	0	1	
5 pounds too light	5	6	12
4 pounds too light	0	0	
3 pounds too light	1	2	
2 pounds too light	6	2	15
1 pound too light	2	2	
Exactly right	0	1	17
1 pound too heavy	1	2	
2 pounds too heavy	0	0	
3 pounds too heavy	9	6	20
4 pounds too heavy	0	1	
5 pounds too heavy	0	1	
6 pounds too heavy	0	0	
7 pounds too heavy	0	1	
8 pounds too heavy	2	0	25
	41	43	

There is a marked tendency to make a large proportion of the estimates in round numbers, 5, 10, 12, 15, or 20 pounds, particularly the last. This tendency is responsible for a very irregular distribution of the judgments. One effect of this is that no distinct mode can be made out. The commonest estimate is 20 pounds, but there are very few other estimates near that, and the next commonest estimate is 10 pounds. Probably the mode should be taken at 10 to 12 pounds, an underestimation of from 5 to 7 pounds. The estimations run down to absurdly small amounts; about 10 per cent of the subjects, both men and women, estimate the 17 pounds at 5 pounds or less.

In this experiment, as in the one last described (*Estimation of Distance*), the B form of the suggestion, encouraging an in-

crease of the estimate, was more effective than the other form, but in this experiment there is a natural tendency, without the suggestion, to underestimate rather than to overestimate, and this tendency is accompanied by a feeling which is the contrary of the feeling in *Distance*. In *Distance* there is a tendency to *overestimate*, accompanied by a feeling that the distance is "not less than" a certain amount, and may be more, while in *Weight* the tendency is to *underestimate* and to feel that the weight is "not more than" a certain amount, and may be less. The conclusion is forced upon us that the greater effectiveness of the B suggestion can not depend upon either the tendency to underestimate or to overestimate or upon the peculiar feelings which accompany these tendencies. It is possible that the individuals who received the B suggestion were really more suggestible individuals than those who received the A set.

The suggestive statement of the A set read: *Note.—Most persons judge the weight to be heavier than it really is.* The B set read "lighter" instead of "heavier".

The degree of suggestibility was measured by the change from the first to the second estimate. The following table proves that the average change was in the direction indicated by the suggestion. The figures show the average estimate of the weight in the first test, when there was no suggestion, and in the second test, when there was a suggestion. They give the amount in pounds. The mean variation of the average estimate is also shown.

	Suggestion A to make lighter		Suggestion B to make heavier	
	Pounds	M.V.	Pounds	M.V.
Women, first test, no suggestion	14.1	5.0	13.3	4.7
Women, second test, with suggestion	11.4	2.7	18.1	7.5
Women, effect of suggestion	*2.7*	......	*4.8*	......
Men, first test, no suggestion	13.0	4.5	12.8	4.5
Men, second test, with suggestion	12.5	4.4	16.2	3.8
Men, effect of suggestion	*0.5*	......	*3.4*	......

Both men and women reduce the second estimate when told (A) that most persons overestimate, and they increase the second estimate if they are told that most persons underestimate (B). Yet, in spite of the consistent average figures, there were a considerable number of persons who failed to respond to the suggestion or who made the second estimate in a way contrary to the intent of the suggestion. The following figures show the proportion (in per cent) of the subjects who failed to respond according to the suggestion.

	Suggestion A	Suggestion B	Both
Women	40%	29%	34%
Men	50	31	42
Both	45	30	38

While the number of persons who resist the suggestion is smaller than in the preceding test (*Distance*), it is still large.

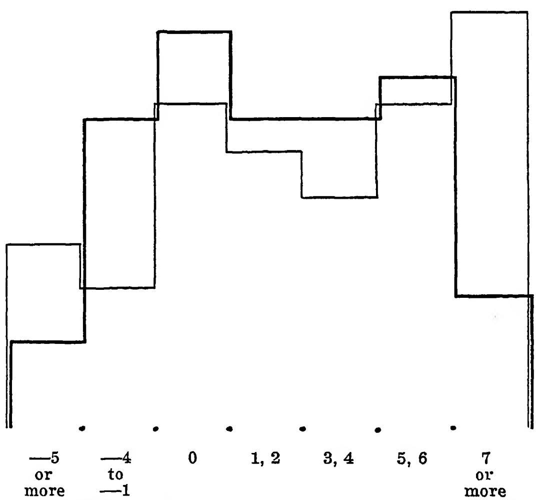


Fig. 24—Estimation of Weight. Light line, women; dark line, men.

Sex differences appear in this test which are very similar to those in the last. The average amount of the influence of the suggestion is greater for women than for men, as was shown above, and more men resist the suggestion or react negatively,

as is also shown above. The graphs for the distribution of the degrees of suggestibility show that a larger proportion of the women are influenced to a comparatively great extent. Of the women, 39 per cent change as much as 5 pounds or more, and 17 per cent change as much as 9 pounds or more, while the corresponding figures for men are only 26 per cent and 2.3 per cent respectively. There can be no doubt that the second judgment of the women is much more gravely affected by the suggestion than that of the men.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who changed their second estimate from their first by the number of pounds indicated. A negative number of pounds means a change contrary to the suggestion.

Change in pounds	Women	Men
—7 or more pounds	4.9	2.3
—5 or —6 pounds	4.9	2.3
—3 or —4 pounds	2.4	7.0
—1 or —2 pounds	4.9	9.3
0 pound	17.1	20.9
1 or 2 pounds	14.6	16.3
3 or 4 pounds	12.2	16.3
5 or 6 pounds	17.1	18.6
7 or 8 pounds	4.9	4.7
9 or 10 pounds	4.9	0.0
11 or 12 pounds	0.0	2.3
Over 12 pounds	12.2	0.0

The distribution for the men is much more compact than that for the women. The women show a peculiar tendency to produce a disproportionate number of individuals who are either extremely suggestible or extremely resistant, so that their judgments fall very far away from the normal.

Only six of the twenty-four separate coefficients of correlation are positive. This is the only one of the seven experiments of this division which shows a distinct preponderance of negative correlations. The coefficients of correlation do not give indications of a close relation between this test and any of the others; the correlation with the *Cross* experiment is the only one with a positive average for the four instances, and that is consistently negative for women.

Correlations Between Suggestibility in the Estimation of Weight and Suggestibility in Six Other Tests

	Women A	Women B	Men A	Men B
Size-Weight	.07	.29	.38	.42
Müller-Lyer	-.30	.31	.14	.07
Distance	.35	-.16	.25	.30
Rectangle	.00	-.20	.00	.52
Triangle	.21	-.45	.25	-.41
Cross	-.07	-.13	.17	.31

This experiment leads to the following conclusions:

1. Women are distinctly more influenced by the suggestion than men.

2. Suggestibility in this experiment is not positively correlated with suggestibility in other tests.

3. The tendency to negative correlation is less distinct among the men than among the women.

3. Conclusions Concerning the Two Experiments Dealing With the Estimation of Magnitudes

In both of these experiments the average judgments show that the suggestion is really effective. Yet there are a considerable number of persons who are able to resist the suggestion The suggestion of the B type proves more effective than the other

Women are more suggestible than men in both experiments and from every point of view.

Estimation of Distance correlates positively, *Estimation of Weight* negatively, with other tests of this division. In spite of the great amount of superficial similarity between the two tests, they do not correlate positively with each other, and, although many persons are able to resist the suggestion of one or the other of them, very few are able to resist them both.

The coefficients of correlation are higher for men than for women in both tests.

IX

FOUR EXPERIMENTS DEALING WITH THE EFFECT OF SUGGESTION UPON SIMPLE ESTHETIC PREFERENCES IN THE MATTER OF THE PROPORTIONS OF GEOMETRICAL FIGURES

1. Rectangle; 2. Triangle; 3. Cross; 4. Line

In these experiments the subject was at first permitted to arrange simple geometrical figures (a rectangle, a cross, etc.) according to his own esthetic judgment. When he came for the second sitting he was given a supplementary statement to the effect that "most persons do so and so" (make the rectangle nearly square, divide the line in the middle, etc.). The amount of the influence of the suggestion was measured by the amount by which the second estimate changed from the first in the direction indicated by the suggestive assertion.

An obvious difficulty arises from the fact that the form of the suggestion was not modified in accordance with the actual choice of the subject. Thus a statement to the effect that "most persons prefer the rectangle almost square" might be given to a person who himself really preferred it almost square or to one who really preferred a very long rectangle. The effect of the suggestion could not be expected to be the same with these different persons. The force of this objection is considerably reduced by the fact that very few people really do prefer either one of the extreme forms described in the suggestive statements; most people prefer (in fact) something between the extremes which are used for suggestion.

In these experiments more than in any of the others we may expect to find "negative" suggestibility, for when an individual reads the assertion that "most people prefer" so and so he may feel it as a challenge to his individual taste and be inclined to

do what only the select few are supposed to do. This difficulty has been avoided in the other experiments of this series by giving the impression that what "most people" do is a mistake which the individual may have committed himself and which he can now correct. In the four experiments of this sub-group the notion of a mistake does not enter. The subject is therefore in a different attitude. Instead of considering himself as one among others, all of whom are liable to make mistakes, he has here to weigh his own judgment against that of the crowd, and he may be influenced *positively,* in the direction of the popular choice, or *negatively,* in opposition to the popular choice. In the following statements the term "suggestibility" will be reserved for the positive reaction in the direction of what is supposed to be the most common, and in so far the most correct, judgment.

1. Rectangle

The first directions, which contained no suggestion, were:

RECTANGLE

You will be shown a rectangle of white cardboard the proportions of which can be adjusted to suit your taste. Let the experimenter adjust the rectangle so that it looks to you to have the most pleasing proportions which it is possible for it to have.

The rectangle had a constant height of 20 centimeters. It hung in a frame on the wall about 3 meters away from the subject. It was mounted on black bristol, and it was adjustable in length by means of a sliding black cover which was uniform with the mounting board. No choice less than the square (20 cm.) was allowed. The changes were made by first opening the rectangle out from the square to its extreme length (70 cm.), then closing it up to the square and opening it up slowly a second time with instructions to the subject to say "stop" when the best shape had been reached. Changes were permitted in case the subject was not quite satisfied with the effect after the operator had stopped.

Some interest may be taken in the actual proportions of the rectangles which were selected in the first part of the experiment

when the choice was not affected in any way by suggestion. The average of the choices of both men and women is not far from the "golden section," that is, a rectangle such that the ratio between the short and long sides of it is equal to the ratio between the long side and the sum of the two sides. The figures show the average length of the preferred rectangle and the mean variation in centimeters.

		M.V.
Average length of women's preference	31.8	3.7
Average length of men's preference	31.7	5.4
Length of "golden section" ($20:L = L:L + 20$)	32.36	......

The distribution of the choices is shown in the following table. It will be remembered that no choice below 20 cm. (the square) was accepted; this accounts for the absence of scattering cases below 20. Otherwise the distribution is quite symmetrical and there is a distinct mode at the average. Evidently the "golden section" does really represent not only the average choice but the choice of the greatest number of individuals, both men and women. Individuals whose preference departs radically from the "golden section" are more apt to be found among the men than among the women. The figures of the table show the actual number of persons of either sex whose preference was for a rectangle of a length within the stated limits.

Length of Rectangle	Women	Men
20 cm. (square)	0	4
21 to 23 cm.	3	2
24 to 26 cm.	2	3
27 to 29 cm.	7	6
30 to 32 cm.	12	13
33 to 35 cm.	10	5
36 to 38 cm.	3	5
39 to 41 cm.	2	1
42 to 44 cm.	2	1
45 to 47 cm.	0	1
48 to 50 cm.	0	0
51 to 53 cm.	0	1
54 to 56 cm.	0	1
	41	43

The suggestive statement used in the A set of directions read as follows: *Note.—Most persons prefer to have one side more than twice as long as the other side.* The other set of directions (B) read: *Note.—Most persons prefer to have the figure nearly square.*

The figures of the following table give the proof that the choice made under the influence of these suggestive statements was really changed from the first choice in the direction of the suggestion. The figures show the average length of the preferred rectangle in the first test, without suggestion, and in the second test, with suggestion. The figures indicate centimeters.

In each of the four groups into which the experiment is divided the change from the first choice to the choice in the second test is in the direction indicated by the directions. A

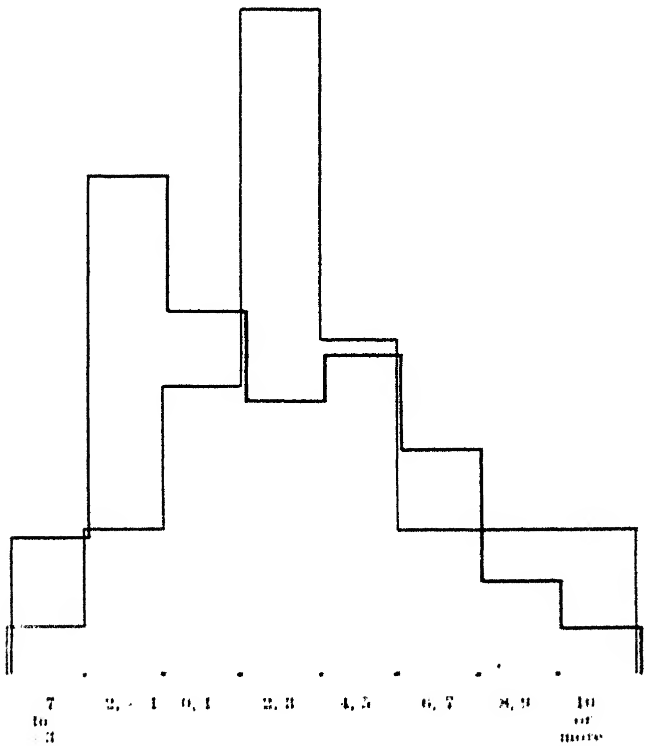


Fig. 25. Rectangle. Light line, women; dark line, men.

change of at least one centimeter in the direction of the suggestion was made by 78 per cent of the women and by 56 per cent of the men.

	Suggestion A to make longer		Suggestion B to make shorter	
	Length	M.V.	Length	M.V.
Women, first test, no suggestion	31.4	3.6	32.2	3.6
Women, second test, with suggestion	36.5	5.5	29.5	3.9
Women, effect of suggestion	*5.1*	......	*2.7*	......
Men, first test, no suggestion	30.0	4.7	34.0	6.2
Men, second test, with suggestion	31.6	5.9	31.3	4.8
Men, effect of suggestion	*1.6*	......	*2.7*	......

From the figures which have already been given it is clear that the women are considerably more subject to the influence of this suggestion than are the men. The graphs for the distribution of different degrees of suggestibility (fig. 25) also show this sex difference. The women show a distinct mode for two or three centimeters of suggestive influence, while the men show a mode at a point below zero. More women are suggestible and a larger proportion of the women are influenced to a comparatively large extent.

Frequency of Different Degrees of Suggestibility

The figures show the percentile proportion of the subjects who were influenced by the suggestive statements to change their second choices from their first choices by the number of centimeters indicated. A minus figure means a change contrary to the suggestion.

Change	Women	Men
—7 cm.	0.0	2.3
—5 cm.	0.0	2.3
—3 cm.	2.4	2.3
—2 cm.	7.3	11.6
—1 cm.	0.0	13.9
0 cm.	9.8	9.3
1 cm.	4.9	9.3
2 cm.	14.6	4.7
3 cm.	19.5	9.3
4 cm.	9.8	9.3
5 cm.	7.3	7.0
6 cm.	4.9	9.3
7 cm.	2.4	2.3
8 cm.	4.9	4.7
9 cm.	2.4	0.0
10 cm. or more	7.3	2.3

There can be no doubt that women are more suggestible than men in this experiment.

The correlations between this test and the other six are nearly as often negative as positive. The correlations are chiefly positive with the other two tests of this esthetic group (*Triangle* and *Cross*) and with *Estimation of Distance*.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE CHOICE OF A RECTANGLE AND SUGGESTIBILITY IN SIX OTHER TESTS

	Women A	Women B	Men A	Men B
Size-Weight	.14	.26	.22	.53
Müller-Lyer	-.04	.02	.24	.15
Distance	.47	.03	.24	.31
Weight	.00	.20	.00	.52
Triangle	.05	.17	.26	.62
Cross	.27	.30	.21	.37

The most important conclusions from this experiment are:

1. Women are more suggestible than men.

2. For men there may be some correlation between suggestibility in this and in other tests, but for women there is not.

2. TRIANGLE

The first directions (without suggestion) were as follows:

TRIANGLE

You will be shown a triangle of white cardboard. The height of thi triangle can be changed to suit your taste without changing the base Let the experimenter adjust the triangle until it seems to you to have th most pleasing proportions which it is possible for it to have.

The base of the isoceles triangle was approximately 19 cm The sides of it were defined by two sliding wings of black bristol By moving a rack up and down the experimenter could var the height without changing the base appreciably. The chang was made by first increasing the height from 8 to 33 cm., the returning to 8 and increasing again slowly until the subject sai "stop".

The spontaneous choice of the subjects, men and women, i the first test, when there was no suggestion, is given below, to

gether with the mean variation. The figures show the average height, in centimeters, of the triangle chosen.

	Height	M.V.
41 women	15.9 cm.	2.8
43 men	16.0	3.6

The height of an equilateral triangle of 19 cm. base would be 16.5 cm. The distribution of the choices is given in the following table. The figures show the actual number of persons who chose a triangle of the specified height.

Height	Women	Men	Height	Women	Men
9 cm.	0	1	20 cm.	0	2
10 cm.	1	0	21 cm.	0	0
11 cm.	1	3	22 cm.	0	1
12 cm.	2	5	23 cm.	1	0
13 cm.	7	7	24 cm.	0	2
14 cm.	7	5	25 cm.	1	1
15 cm.	8	7	26 cm.	1	2
16 cm.	4	1	33 cm.	1	0
17 cm.	4	1			
18 cm.	1	2		41	43
19 cm.	2	3			

There is a distinct mode in this distribution for the heights of 13, 14, or 15 cm. The comparatively large number of scattering choices above 20 cm. is responsible for bringing the average up to 16 cm. The common choice of a triangle about 14 cm. high undoubtedly represents an effort to secure an equilateral triangle, for a true equilateral triangle 16.5 cm. high does not appear to be equilateral, but seems to have its sloping sides longer than its base.

No important sex differences appear in the original choices of the most pleasing triangle.

The supplementary statements intended for suggestion were similar to those used in the preceding experiment. Form A asserted that *most persons prefer a triangle in which the height is about twice as great as the base,* while form B said that *most persons prefer a triangle in which the height is only about half as great as the base.* The actual amount of difference, in centimeters, between the height in the first choice and the choice made

three weeks later under the influence of a suggestive statement has been taken as the measure of suggestibility in this experiment. The following table contains the proof that the second judgment was really affected by the suggestion. The figures show the average height of the preferred triangle, in centimeters, together with the mean variation, both in the first trial, without any suggestion, and in the second trial, when there was a suggestion.

For both men and women the second test shows a decided change in the direction indicated by the suggestion, and this is true in both divisions of the experiment. Moreover, the original data show that a change of at least one centimeter in the direction of the suggestion was made by 58 per cent of the women and 65 per cent of the men.

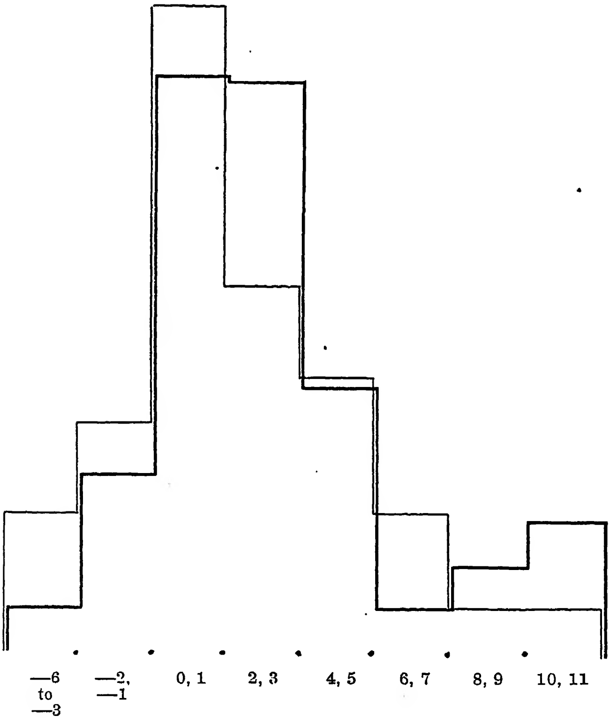


Fig. 26.—Triangle. Light line, women; dark line, men.

	Suggestion A to make higher		Suggestion B to make lower	
	Height	M.V.	Height	M.V.
Women, first test, no suggestion	15.8	3.0	16.1	2.7
Women, second test, with suggestion	17.8	3.6	14.9	2.7
Women, effect of suggestion	*2.0*	.....	*1.2*	.....
Men, first test, no suggestion	15.2	2.7	17.1	3.8
Men, second test, with suggestion	17.5	3.3	14.3	2.4
Men, effect of suggestion	*2.3*	.....	*2.8*	.....

The sex difference in this experiment is conspicuously different from that which has been found in most of the experiments. The men are more influenced by the suggestion under both the A and B forms, particularly under the latter, and more individual men than women are influenced to the extent of one centimeter or more. The distribution of the degrees of suggestibility (fig. 26) shows also that the men are more suggestible.

FREQUENCY OF DIFFERENT DEGREES OF SUGGESTIBILITY

The figures show the percentile proportion of the subjects who changed their second estimate from their first by the number of centimeters specified. A negative figure means a change in the direction opposite to that indicated by the suggestion.

Change	Women	Men	Change	Women	Men
—6 cm.	4.9	0.0	4 cm.	7.3	7.0
—5 cm.	2.4	2.3	5 cm.	7.3	7.0
—2 cm.	4.9	2.3	6 cm.	4.9	2.3
—1 cm.	7.3	7.0	7 cm.	2.4	0.0
0 cm.	21.9	23.3	8 cm.	0.0	2.3
1 cm.	12.2	7.0	9 cm.	2.4	2.3
2 cm.	9.7	13.9	10 cm.	2.4	4.7
3 cm.	9.7	16.3	11 cm.	0.0	2.3

When the rankings in this test are correlated with the rankings in the other six tests it is found that 17 of the 24 coefficients are positive. The only test with which there is a negative correlation when the four coefficients are averaged is *Estimation of Weight*. The correlation is high for men with the closely related test *Rectangle*, but not so for the women. On the other hand, the test with the *Cross*, which resembles both *Triangle* and *Rectangle* in general method, shows a good correlation for women, but not for men.

CORRELATIONS BETWEEN SUGGESTIBILITY IN THE CHOICE OF A TRIANGLE AND SUGGESTIBILITY IN SIX OTHER TESTS

	Women A	Women B	Men A	Men B
Size-Weight	—.32	.33	.12	.38
Müller-Lyer	.16	.38	.21	.20
Distance	.03	.06	—.02	.64
Weight	—.21	—.45	.25	—.41
Rectangle	.05	—.17	.26	.62
Cross	.37	.16	.18	—.11

In conclusion it may be said that:

1. Men are clearly more suggestible in this test than are women.

2. The correlations between this test and others are positive for the most part, but more clearly so for men than for women.

3. PROPORTIONS OF A CROSS

The first directions, involving no intentional suggestion, were as follows:

PREFERRED PROPORTIONS OF A CROSS

You will be shown a black cross which is so constructed that you can adjust the cross-piece in any position on the vertical piece according to your taste. You are asked to adjust the cross so that the cross-piece is in a position where it seems to you to produce the most pleasing effect.

The cross was made of black cardboard mounted on a sheet of white bristol. The bars were one centimeter wide. The vertical piece was 56 cm. long and the cross-piece was 36 cm. long. It was hung up with the middle of the vertical piece about at the level of the eyes. The adjustment was made by the subject himself. The subject was not permitted to place the cross-piece below the middle of the vertical piece, even if he desired to do so, which seldom happened.

The arrangement of the cross which is generally chosen is indicated by the following figures. The figures show the average length of the head-piece, that is, the average distance of the cross-piece from the top of the vertical piece.

	Length	M.V.
41 women	16.9 cm.	2.3
43 men	15.5	1.9

The "golden section" of the vertical piece considered alone would give a head-piece of 21.4 cm. The length of the head-piece would be 11.1 cm. if it stood in the golden ratio to the arm (18 cm.) of the cross.

The actual number of persons who arranged the cross with a head-piece of various lengths is shown below.

Length	Women	Men	Length	Women	Men
10 cm.	0	1	19 cm.	4	4
11 cm.	1	1	20 cm.	0	1
12 cm.	0	3	21 cm.	2	0
13 cm.	3	4	25 cm.	1	1
14 cm.	4	5	26 cm.	1	0
15 cm.	5	4	28 cm. (middle)	1	0
16 cm.	9	11			
17 cm.	6	5		41	43
18 cm.	4	2			

There is a distinct mode at 16. The distribution about this mode is fairly symmetrical, except for four individuals who chose to place the cross-bar near the center of the vertical piece. The data do not show any very consistent sex differences with regard to the simple choice of proportions for the cross. Cases of an unusually high position for the cross-bar are more common among the men, and three of the four very low cases were women, with the result that the average position is nearer the top for the men than for the women. But an inspection of the complete distribution shows that the average made up in this way is not a fair index of the relation between the sexes.

The suggestive statements given to the subjects in the second test were very similar to those used in the last two experiments (*Rectangle* and *Triangle*). The A form said that *most people place the cross-piece quite near the top;* the B set said that *most people place the cross-piece almost in the middle.* The choice at the second sitting was actually affected by the form of the suggestion, as is shown below. The figures show the average distance of the cross-bar from the top of the vertical piece as adjusted at the first sitting, without suggestion, and as adjusted

at the second sitting under the influence of the suggestive statement.

	Suggestion A to make shorter		Suggestion B to make longer	
	Distance	M.V.	Distance	M.V.
Women, first test, no suggestion	17.3	3.0	16.5	2.0
Women, second test, with suggestion	14.8	3.2	17.4	2.9
Women, effect of suggestion	*2.5*	.....	*0.9*	.....
Men, first test, no suggestion	15.5	1.7	15.5	2.3
Men, second test, with suggestion	15.4	2.1	15.9	2.0
Men, effect of suggestion	*0.1*	.....	*0.4*	.....

Each of the four groups of subjects gave judgments in the second test which differed from their judgments in the first test in the direction indicated by the suggestion. Although the change is not large enough in some of the groups to have any significance in itself, it acquires significance from the agreement of the groups with one another and from the fact that a similar tendency to conform to the suggestion has been shown in the experiments with *Rectangles* and *Triangles*. It will be noted that the absolute amount of the average change of judgment is not so great in this experiment as in the other two. The change amounted to one centimeter or more with 56 per cent of the women and 44 per cent of the men.

Women are more suggestible in this test than men; a larger proportion of them yield to it, and the average amount of the influence of the suggestion is considerably greater among them. The distribution of the degrees of suggestibility, shown in the graph (fig. 27), indicates that women are much more apt to be influenced to a considerable extent by the suggestion. Only two men, or 4.7 per cent, change their judgment as much as 4 cm., while ten women, or 24.4 per cent, change 4 cm. or more in the direction of the suggestion.

This test gives relatively good correlations with all of the others. Except for *Estimation of Weight,* three of the four groups give positive correlations for each test, so that seventeen

Frequency of Different Degrees of Suggestibility

The figures show the percentile proportion of the subjects whose second arrangement of the cross differed from their first arrangement by the number of centimeters indicated. A negative figure means a change in the direction opposite to that indicated by the suggestive statement.

Change	Women	Men	Change	Women	Men
—14 cm.	2.4	0.0	2 cm.	9.8	18.6
—10 cm.	0.0	2.3	3 cm.	17.1	9.3
— 9 cm.	2.4	0.0	4 cm.	4.9	2.3
— 5 cm.	0.0	2.3	5 cm.	7.3	2.3
— 4 cm.	2.4	2.3	7 cm.	2.4	......
— 3 cm.	2.4	0.0	8 cm.	2.4	......
— 2 cm.	9.8	9.3	10 cm.	2.4	......
— 1 cm.	7.3	16.3	15 cm.	2.4	......
0 cm.	12.2	20.9	17 cm.	2.4	......
1 cm.	9.8	14.0			

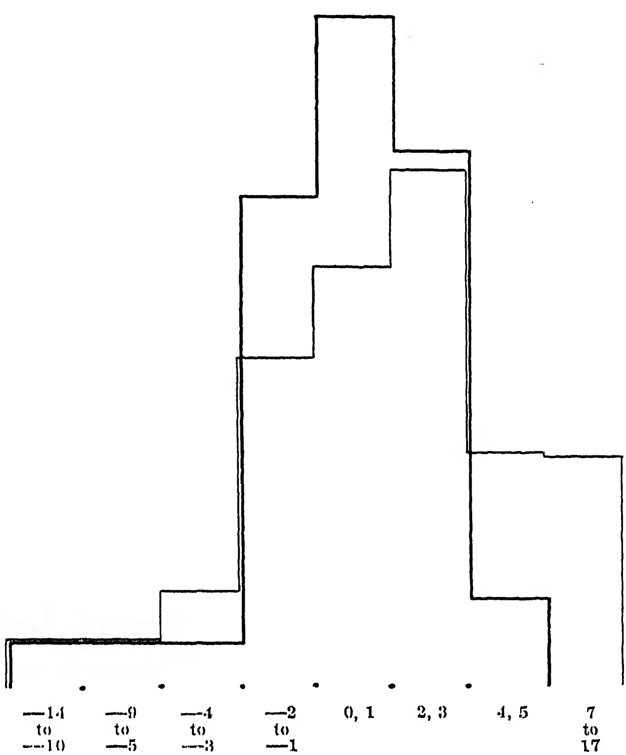


Fig. 27—Cross. Light line, women; dark line, men.

of the twenty-four coefficients are positive. The correlations with the other tests of this sub-group (*Rectangle*, *Triangle*) are positive, but no greater in amount than for tests which lay no claim to close relationship with this one.

Correlation Between Suggestibility in Regard to the Proportions of a Cross and Suggestibility in Six Other Tests

	Women A	Women B	Men A	Men B
Size-Weight	.02	.05	.28	.15
Müller Lyer	-.13	.34	.06	.21
Distance	.16	.31	.45	.29
Weight	-.07	-.13	.17	.31
Rectangle	.27	.30	.21	.37
Triangle	.37	.16	.18	.11

In conclusion it may be said that:

1. Women are decidedly more suggestible than men in this test.

2. There are positive correlations between this and the other tests of this group.

3. The correlations are positive more often and more clearly for women than for men, which is exceptional.

4. Division of a Line

The "line" referred to in this experiment was a black cardboard strip one centimeter wide and 56 cm. long attached by its ends horizontally to a sheet of white bristol. A small black cross-piece 1 cm wide and 2.5 cm. long slid back and forth on this "line". The subject made his own adjustment of the position of the cross-piece on the line. Either the left or the right-hand portion of the line could be made longer than the other portion, according to the preference of the subject, but in either case it was the shorter portion which was measured.

The original directions were:

PREFERRED PROPORTIONS OF A LINE

You will be shown a black line on which there is a sliding piece which you can adjust so as to divide the line in any proportion to suit your taste. You are asked to adjust the line so that the small sliding piece divides the line in what appears to you to be the most pleasing proportion.

The suggestive statements which were given to the subjects at the second sitting were almost identical in form with those used in the experiment last described (*Cross*). The A form said that *most persons make one part very short and the other part very long.* The B form said *most persons divide the line into two equal or nearly equal parts.*

Many subjects regarded this experiment as quite foolish, asserting that the division of the line did not interest them; yet a surprising number made the adjustment of the second sitting approximately the same as that of the first sitting. In fact the number of persons who resisted the suggestion (in spite of their assertion that they did not care much where the line was divided) was so great that the data from the experiment prove to be of very little value. The following figures show how few persons were influenced to an appreciable extent by the suggestion or changed much from their first choice. The figures are the actual number of subjects.

	Women	Men
No change, or a change of 3 cm. or less	32	36
Change in the direction of the suggestion of over 3 cm.	5	6
Change opposite to the suggestion of over 3 cm.	4	1

The value of this experiment is also diminished by the fact that many persons do, as a matter of fact, prefer the line divided about in the middle, so that one form of the suggestion fails of its purpose in so far as it does not call for any change, in numerous instances, from the first choice. This difficulty has been present in the other experiments of this group, but not to the same extent. The following figures show the actual number of persons who, at the first sitting, chose to divide the line in the middle or not more than 2 cm. from the middle, and also the number of those who were affected by the suggestion to the extent of leaving the middle or of coming to the middle. In computing these figures a choice within 2 cm. of the middle of the line is counted as a preference for the middle.

Among 20 women, A, 8 first chose the middle, of whom 1 yielded to the suggestion by leaving the middle.

Among 21 women, B, 10 first chose the middle, and 2 others chose the middle under suggestion in the second test.

Among 24 men, A, 10 first chose the middle, of whom 3 yielded later to the suggestion by leaving the middle.

Among 19 men, B, 10 first chose the middle, and 3 others chose the middle under suggestion in the second test.

The following figures show the average length of the short portion of the line in the first test, without suggestion, and in the second test, under the influence of a suggestive statement.

	Suggestion A to make shorter	Suggestion B to make longer
Women, first test, no suggestion	22.4 cm.	23.4 cm.
Women, second test, with suggestion	22.5	24.3
Women, effect of suggestion	*—0.1*	*0.9*
Men, first test, no suggestion	21.5	22.7
Men, second test, with suggestion	19.9	23.6
Men, effect of suggestion	*1.6*	*0.9*

From these figures it appears that the average position of the division is affected to some degree in the direction of the suggestion in three of the four groups of subjects.

The effect of the suggestion is more pronounced among the men than among the women. Not only is the average influence more marked among the men, but the number of men who desert their first choice at the middle, or who change to the middle under the influence of the suggestion, is greater, and fewer of them make a distinct change in the direction away from that indicated by the suggestion.

On account of the unsatisfactory nature of the measurement obtained in this experiment no attempt has been made to obtain coefficients of correlation with other experiments.

The only conclusion which the data warrant is that men are more apt than women to be influenced by the suggestion employed in this test.

5. Conclusions Concerning the Four Experiments Which Involve Esthetic Judgments of Proportion

These four experiments are very closely related in respect to method and the general form of the suggestive statement. The results prove that each of the three for which coefficients of correlation have been calculated is positively correlated with the other two. Yet the correlations are not large enough, either absolutely or by comparison with the correlations found with other and less obviously related tests, to warrant the inference that the three (or four) suggestions act upon the subject in the same way. A person who is highly suggestible in one of these experiments is more apt than another to prove highly suggestible in another of these tests, but not much more apt to prove so in one of these supposedly related tests than in some other test.

With regard to sex differences, these experiments are not consistent with one another. Two of them, *Rectangle* and *Cross,* seem to indicate very clearly that women are more apt than men to respond to the suggestion by changing their preference in the direction of what they suppose "most persons" prefer. On the other hand, *Triangle,* which does not seem to differ in any essential respect from *Rectangle,* gives exactly the opposite sex difference with equal distinctness; and *Line,* although not very trustworthy on account of the fact that at least 80 per cent of the subjects proved wholly immune to the suggestion, shows that among the few persons who are at all subject to the suggestion there are more men than women.

THREE EXPERIMENTS DEALING WITH THE EFFECT OF SUGGESTION UPON SIMPLE ESTHETIC PREFERENCES IN THE QUALITY OF SENSATIONS

1. Preference for a Simple Color; 2. Preference for Tone; 3. Preference for a Color Combination

None of these three experiments can be regarded as a success from the quantitative point of view. The measurements which could be made were so coarse and the sources of error so manifest that no statement whatever seems warranted concerning individual differences, and what is to be said concerning sex differences must be regarded as merely approximate and of no consequence except in so far as the findings are found to agree with what has been learned from those experiments in which more exact measurements have been made.

1. Preference for a Single Color

The material for this experiment consisted of a dull black card on which were mounted eleven pieces of "Hering" colored paper 4 cm. wide and 9 cm. high. The pieces were mounted in a single horizontal row, separated from one another by a space of 2 cm. The colors were in the order of the spectrum from left to right: light red, dark red, orange, yellow, etc., to purple. The violet red was not included.

This experiment was given at the same time with the experiments of the second group of the first main division (see p. 294) but in its general method it is more closely related to the tests of the second main division, now being described. The precis

form of the suggestion is not like that used in any of the other tests. The directions were as follows:

PREFERENCE FOR COLORS

It is the object of this experiment to obtain information about the color preferences of men and women. It is generally said that *men* like reddish, ruddy, or warm colors, while *women*, as a rule, dislike them.

All that you have to do is to pick out the color that you like best in the set shown.

The directions were arranged in two sets. One set read as above, "men like . . . while women . . . dislike"; the other set read, "women like . . . while men . . . dislike." The two sets differed from each other only in interchanging the words *men* and *women*. These words are printed in italics here in order to make clear their significance; they were not italicized in the statements given to the subjects. It was intended that half of the subjects should receive one set of directions, the other half the other set. A person is counted as suggestible if he selects a color among the five beyond the middle of the set and toward the end which is indicated by the directions as being preferred by his own sex. But of course this method of measurement is highly arbitrary. The form of the suggestion itself is not free from misinterpretation, as, for example, in the case of the man who is influenced by the reflection that women have better taste than men in such matters.

Unfortunately the number of persons of either sex who received one set of directions was not exactly equal to the number who received the other set. Moreover, the preference for *blue*, among the colors used, was so strong with both men and women that the suggestion seems to have been very often ineffective when brought into conflict with it.

No clear sex differences appear. A color toward the blue end of the spectrum is preferred by 72 per cent of the women and by 73 per cent of the men, regardless of the suggestive statement. The choice was in accord with the positive suggestion in the directions for 57 per cent of the 75 women tested and for 55 per cent of the 60 men. The work of the separate experimenters is so inconsistent as to deprive these figures of real significance.

2. Preference Between Two Tones

This experiment takes us back to the group in which a norm was established by a preliminary sitting before the suggestion was given. The first directions were as follows:

PREFERENCE FOR TONES

You will hear two tones, first one produced by a metal whistle and then one produced by a wooden whistle. They are the same in pitch. Each will be sounded for ten seconds, and then each will be sounded again for five seconds. You are to say which one is the more pleasing to you.

The tones were produced by a brass Stern *tonvariator* and an Appunn wooden organ-pipe ("Ut 4"). The instruments were attuned at 495 vs, according to the tonvariator, and were blown from the same air tank. They were of about the same loudness. The wood had more noticeable overtones. It was found that 76 per cent of the women and 74 per cent of the men actually prefer the metal.

When the subject returned for the second sitting three weeks after the first test he received one or the other of the following suggestive statements appended to the foregoing directions. Form A said: *Note.—Most persons prefer the metal whistle.* Form B said *wooden.* The experiment might have proved more satisfactory if the suggestive statement had been altered to fit the first choice of each subject, so that in each case the subject would have been confronted with a suggestion to *change* from his former judgment. As the suggestions were actually given in a chance order the data are considerably more complicated.

Of the 41 women, 13 change their minds between the first and second sittings, and 8 of the 13 change in the direction of the suggestion. Of the 43 men, 11 change their minds, and 6 of the 11 change in the direction of the suggestion. The following figures show that most of the changes occurred under the direction of suggestion "B" (to prefer wood).

The unexplained but obvious tendency to change from metal to wood is strong enough in the A group, where it involves a negative response to the suggestion, to prevent many changes.

But in the B group the spontaneous tendency to change toward wood reinforces the suggestion, with the result that more changes occur.

	Positive change	Negative change
20 women, A	1	2
24 men, A	2	3
21 women, B	7	3
19 men, B	4	2

The amount by which women appear to be more suggestible than men is entirely negligible, except perhaps that the apparent difference between the sexes happens to be in the same direction as the difference which has been found more clearly in many of the other experiments.

3. Preference for a Combination of Two Colors

The original directions, which were not supposed to be suggestive, were:

PREFERRED COMBINATION OF COLORS

You will be given a card with a piece of colored paper mounted on it, and you will be shown a large card on which a great variety of colors are mounted. You are asked to pick out the color which you think would make the most pleasing combination with the one that is given you.

All of the 90 colors from a Milton Bradley sample book (size 3.7 by 7 cm.) were mounted vertically in columns of five on a large black card with space between them equal to half the width of the colored strip. The five tints and shades of each color appeared in a single vertical column. The columns were designated by letter (violet red was A and red violet was R), and the rows were designated by number, row 3 being the best saturated color. The one color used as the basis of the combinations was the Milton Bradley "green". The green strip was of the same size as the other strips and was mounted on a small black card. The subject held this card in his hand and placed it alongside of the colors in the set whenever he liked.

One set of suggestive directions read: *Note.—Most persons select a color from one of the columns marked by the letters B, C, or D* (these colors were red, orange-red, and red-orange). The "B" set read: *Note.—Most persons select a color from one of the columns marked by the letters H, I, or J* (these colors were yellow, green-yellow, and yellow-green).

In the preliminary test the two groups of colors mentioned in the suggestive statements actually contained about an equal number of choices, and between them they embraced nearly three-fourths of all the choices.

In the original choices, without suggestion, no difference of a systematic sort could be discovered between the preferences of men and women. About 35 per cent of the members of each sex prefer with green a color which contains a large admixture of red (red-violet, violet-red, red, orange-red, or red-orange). The first choice is yellow, which is preferred by 14 per cent of the subjects. For the second place, red is tied with yellow-green (11 per cent for each of these colors).

Men show a stronger preference than women for well saturated colors in combination with the saturated green. Women show a much stronger preference for tints. The following figures show the proportion of the subjects who chose, as making the best combination with the saturated green, another saturated color, a tint, or a shade darker than the saturated color.

Choice	Women	Men
Tints	41%	9%
Saturated colors	27	60
Darker shades	32	30

The following figures show the actual number of persons, both men and women, who preferred one of the designated colors either in the first test, when there was no suggestion, or in the second test. In the second test the change in the number of persons who chose one of the designated colors may, or may not, be ascribed to the influence of the suggestive statements.

	Chose red, orange-red, red-orange	Chose yellow, green-yellow, yellow-green
20 women, A group, first test, no suggestion	6	7
20 women, A group, second test, with suggestion	12	3
Increase, ascribed to the suggestion	*6*	.....
21 women, B group, first test, no suggestion	2	6
21 women, B group, second test, with suggestion	3	9
Increase, ascribed to the suggestion	.....	*3*
24 men, A group, first test, no suggestion	7	8
24 men, A group, second test, with suggestion	9	4
Increase, ascribed to the suggestion	*2*	.....
19 men, B group, first test, no suggestion	5	4
19 men, B group, second test, with suggestion	4	6
Increase, ascribed to the suggestion	.....	*2*

In each of the four groups the suggestion is effective, for the specified colors are chosen more often in the second test if the statement recommends such a choice, and not otherwise. If the results are combined in order to make the sex differences clear we obtain the following figures, showing the per cent of persons who chose the specified colors.

	Women	Men
Without suggestion	29%	26%
Under suggestion	51	35
Increase due to suggestion	*22*	*9*

On the other hand, the per cent of persons who chose one of the three colors which were *not* specified in their own directions, but were specified, without their knowledge, in the directions of their co-subjects was as follows:

	Women	Men
First test, no suggestion	22%	30%
Second test, no suggestion	15	19
Withdrawals, instead of increase	*7*	*11*

These figures are introduced only for the purpose of showing that the increase in the number of preferences for the specified colors did not arise from a general tendency to change over to the six colors used for the suggestions. The changes which were made were not toward all of the six, but toward only the three mentioned and away from the three not at that time mentioned.

The figures above show that the number of women who can be induced to change from an expression of preference for one combination of colors to another by the statement that "most persons prefer" the second combination is considerably greater than the number of men who can be induced to change in this way.

It will have been observed that these figures take into consideration only the final results of all the changes, including the cases of those who at first preferred one of the designated colors and then changed away from it in spite of the suggestion. The following figures show the number of persons (in per cent) who adopted the designated colors, having first preferred some other, no account being made of those who originally preferred these colors and for whom the suggestion only served as a confirmation of their natural preference. The figures are the per cent of the subjects who change from some other color in the manner indicated.

	Women	Men
Change to one of the 3 suggested colors	24%	16%
Change to one of these 3 when not suggested	7	5

These figures further confirm the conclusion that women are more open than men to this suggestion.

4. Conclusions From the Three Experiments Depending Upon a Simple Esthetic Preference

The test for *Color Preference,* in which the suggestion is hidden under the assertion that *men* or that *women* prefer certain classes of colors, gives no results worth considering; the actual preferences are too strong for the suggestion.

The preference between two *Tones* is too strong also for the suggestion to affect it much. But in this case there are a very few instances in which women appear more suggestible than men.

The preference for *Color Combinations* is susceptible of change through suggestion, and in this case women are considerably more apt to respond to the suggestion than men.

XI

FINAL CONCLUSIONS CONCERNING SEX DIFFERENCES IN SUGGESTIBILITY

A general review of the entire series of twenty-six experiments reveals a very distinct difference between the sexes. In thirteen of the experiments there is a clear difference between the sexes, and in only one of these experiments are the men more suggestible. There is a slight, but still fairly reliable, difference in four other tests, and in only one of these are the men more suggestible. There are five tests in which the difference between the sexes is rather doubtful, and in only one of these does it appear probable that the men are more suggestible. There are only four experiments in which no sex difference can be made out. The following table shows the experiments arranged in the order in which they have been presented in this report. An entry under the caption *Women* means that women proved clearly or somewhat more suggestible than men, or that there is a distinct probability that they are more suggestible. An entry under *Men* is to be interpreted in the same terms. No entry, under either heading, means that the data are inadequate or self-contradictory. The page reference is to the page on which the discussion of the sex difference in that experiment is begun.

The difference between the sexes is more distinct in some of the groups of experiments than in other groups. There can be little doubt that women are more suggestible in tests which involve an imagined sensation, a series of progressive changes, distortion of memory, and estimation of magnitudes. The tests with illusions do not give clear differences between the sexes, and the tests with esthetic judgments give contradictory or indecisive results. Where degree of suggestibility is measured by the promptness of the response to the suggestion women are not conspicuously more suggestible than men. Two of the tests of this kind (*Change of Size* and *Heat*) give no sex difference; two

Page	*Least perceptible (imagined) Sensations:*	Women	Men
299	Odors	Clearly	
304	Touch	Clearly	
310	Heat	———	———
316	Electric Shock	Clearly	
	Least perceptible (imagined) Change:		
324	Change of Brightness	Somewhat	
327	Change of Pitch	Clearly	
330	Change of Size	———	———
334	Motion	Somewhat	
	Series of progressive Changes:		
341	Progressive Weights	Clearly	
345	Progressive Lines	Probably	
	Memory, Recognition, Imagination:		
350	Recognition of Form (Checkerboard)	Clearly	
352	Recognition of Position (Letters)	Somewhat	
356	Memory for Size (Squares)	Probably	
361	Memory for Pictures	Probably	
364	Ink-blot Test of Imagination	Clearly	
	Illusions:		
373	Size-Weight	———	Probably
379	Müller-Lyer	Somewhat	
	Estimation of Magnitude:		
389	Estimation of Distance	Clearly	
394	Estimation of Weight	Clearly	
	Esthetic Preference, Proportions:		
401	Rectangle	Clearly	
405	Triangle	———	Clearly
408	Cross	Clearly	
412	Division of a Line	———	Somewhat
	Esthetic Preference, Qualities:		
415	Preference for a single Color	———	———
416	Choice between two Tones	———	———
419	Color-combination	Clearly	

(*Brightness* and *Motion*) give a slight difference, and only *Change of Pitch* gives a clear difference.

The fact that women are more suggestible than men in the greater part of these tests can not be construed immediately as proof that women as a class are more "suggestible" than men. Tests of a different character, involving verbal suggestions or suggestions of a different kind, might not yield the same results. Yet it should be noted that two quite different types of suggestion were actually employed in these experiments, one in which a false or misleading statement was concealed in the directions, and, in some cases, supported by a false or misleading "demonstration", and the other in which the suggestion was presented in a comparatively open manner under the guise of a statement of information concerning what "most people" do under the circumstances. In both of these forms of suggestion, and in distinctly different variations of both forms, the greater suggestibility of women is apparent. This circumstance makes it seem highly improbable that the apparent difference between the sexes is wholly dependent upon the peculiar manner of presenting the suggestion.

A sweeping conclusion concerning the difference between the sexes should not be made without considering the question whether the men and women who acted as subjects in these experiments were typical representatives of their respective sexes. These young men and women come from the same communities and home conditions. It is difficult to see how any difference of an environmental or hereditary sort can exist between the representatives of the two sexes. Nor is it apparent that there has been any selection from the members of either sex. The men are not drawn to any appreciable extent from engineering or technical departments of the University, but are the men who elect to take general "cultural" courses which are pursued by most women in the University. From earliest childhood these boys and girls have been subjected to precisely the same conditions so far as education is concerned. Most of them have always attended coeducational schools. There is no apparent reason

why these young men and women should not be regarded as typical representatives of the younger men and women from the more prosperous families of this community.

Abstaining, however, from any generalizations outside of the actual scope of the investigation, we may fairly conclude that wherever written directions are used which give rise to false anticipations, or which contain statements concerning the usual course of most persons, these directions will prove more misleading to women students than to men.

XII

FINAL CONCLUSIONS CONCERNING INDIVIDUAL DIFFERENCES IN SUGGESTIBILITY

The question whether particular individuals possess a characteristic trait which may be called "suggestibility" and which will distinguish them from other individuals in a number of different situations has already been answered in part affirmatively with the assertion that women are, as a rule, more suggestible than men. The assertion of a sex difference is the assertion that some individuals (one sex) possess a characteristic in which they differ from other individuals (the other sex). In the present case the obviousness of the difference between the sexes in the great majority of the experiments compels the conclusion that there is a common trait "suggestibility" which appears in a variety of circumstances and which is more conspicuous in women than in men. The further question remains whether there are consistent differences in suggestibility between different individuals of the same sex.

It must be said at once that there are no individual differences which are sufficiently conspicuous to justify the experimenter in calling one person "very suggestible" and another "not suggestible." There are no individuals who have consistently high or consistently low indices of suggestibility through a series of tests.

On the contrary, the experimenter is struck by the fact that the most skeptical individual will yield at times with surprising readiness to the suggestion, while a person who has yielded to some tests with very little apparent resistance will unexpectedly become very recalcitrant. But it must be remembered that the absence of conspicuous cases of high suggestibility or of low suggestibility consistently maintained throughout a number of tests can not be taken as proof of the absence of a *tendency* in certain individuals to be suggestible or to resist suggestion.

The coefficients of correlation do afford an indication of the presence or absence of a tendency to respond to the suggestion in one test in the same general way as in other tests. A high coefficient of correlation indicates that the individuals who are suggestible in one test are suggestible in the other, and if there is a positive coefficient, even though it is a low one, it affords reason for believing that suggestibility is a trait which reappears in an individual from time to time under a variety of conditions. The following table presents certain data which may be considered in this connection. The figures are obtained by adding together the coefficients of correlation for each of the tests with each of the others in that division of the experiment and taking the average of these different coefficients. In the case of the first division there are nine tests, so that the average is based on eight figures, each of which is obtained from an array of 54 women and 29 men. In the case of the second division there are seven tests for which correlations have been calculated, so that the average rests on six correlations for the A group and six for the B group, or twelve in all. There were about 20 persons of each sex in each of these groups. The absence in the table of any figure for the correlation means that correlations were not calculated for that experiment. In two cases (*Electric Shock* and *Ink Blot*) there were no correlations calculated for the large groups of subjects, but correlations calculated for the subjects of separate experimenters were generally positive. The page reference at the left refers to the page on which the discussion of correlations is taken up in the case of each experiment.

Page		Correlations Men	Correlations Women
	Least perceptible (imagined) Sensations:		
301	Odors	.039	.147
307	Touch	.110	.220
312	Heat	.030	.098
318	Electric Shock	......	......
	Least perceptible (imagined) Change:		
324	Change of Brightness	.050	.275
328	Change of Pitch	.048	.200
332	Change of Size	.061	.281
336	Motion	—.084	.209
	Series of progressive Changes:		
343	Progressive Weights	.074	.181
347	Progressive Lines	.074	.126
	Memory, Recognition, Imagination:		
351	Recognition of Form (Checkerboard)	......	......
353	Recognition of Position (Letters)	......	......
359	Memory for Size (Squares)	......	......
360	Memory for Pictures	......	......
366	Ink-blot Test of Imagination	......	......
	Illusions:		
377	Size-Weight	—.054	.162
383	Müller-Lyer	.052	.014
	Estimation of Magnitude:		
390	Estimation of Distance	.030	.167
395	Estimation of Weight	—.200	—.042
	Esthetic Preference, Proportions:		
402	Rectangle	.022	.092
405	Triangle	.032	.193
408	Cross	.137	.079
412	Division of a Line	......	......
	Esthetic Preference, Qualities:		
415	Preference for a single Color	......	......
416	Choice between two Tones	......	......
417	Color-combination	......	......

The figures obtained by averaging the correlations are none of them high, but among the thirty-two there are only four which are negative. The combined average for men in the 9 experiments of the first division is .204 and for the women it is .054. In the 7 experiments of the second division it is .095 for men and practically zero (.003) for women. The separate figures from which these averages have been obtained are given on pages 427 and 428. The upper right-hand and lower left-hand portions of these pages are duplicated in order to show the full column of correlations for each one of the tests. It is understood that these correlations involve a possible error, in that the work was done by different experimenters, so that the ranking of the individual subject's record may be influenced by the amount of the personal influence of the experimenter. This source of error was eliminated in the experiments of the first division by computing separate coefficients of correlation for each experimenter.

CORRELATIONS BETWEEN TESTS OF THE FIRST DIVISION

Women (54 cases) in the upper line and men (29 cases) in the lower line.

	Odors	Touch	Heat	Brightness	Pitch	Size	Motion	Weights	Line
Odors	......	—.01	.11	.05	—.10	.08	—.28	.18	.28
	......	.23	.26	.40	.16	.39	.14	.16	.24
Touch	—.01	......	.35	.15	.27	.04	.07	—.13	.14
	.23	......	.19	.42	.15	.30	.19	.11	.17
Heat	.11	.35	......	.07	—.29	.04	—.24	.05	.15
	.26	.19	......	.04	.06	.26	.09	—.16	.04
Brightness	.05	.15	.07	......	.18	—.16	—.05	.22	—.06
	.40	.42	.04	......	.38	.09	.39	.40	.08
Pitch	—.10	.27	—.29	.18	......	.04	.16	.07	.05
	.16	.15	.06	.38	......	.46	.09	.38	—.08
Size	.08	.04	.04	—.16	.04	......	.12	.27	.06
	.39	.30	.26	.09	.46	......	.36	.22	.17
Motion	—.28	.07	—.24	—.05	.16	.12	......	—.24	—.20
	.14	.19	.09	.39	.09	.36	......	.18	.23
Weights	.18	—.13	.05	.22	.07	.27	—.24	......	.17
	.16	.11	—.16	.40	.38	.22	.18	......	.16
Lines	.28	.14	.15	—.06	.05	.06	—.20	.17	......
	.24	.17	.04	.08	—.08	.17	.23	.16	..

Correlations Between Tests in the Second Division

First line, 20 women under suggestion A; second line, 21 women under suggestion B; third line, 24 men under suggestion A; fourth line, 19 men under suggestion B.

	Size-Weight	Müller-Lyer	Distance	Weight	Rect-angle	Tri-angle	Cross
Size-Weight	......	.05	—.09	.07	—.14	—.32	.02
	......	.21	—.28	—.29	—.26	.33	.05
	......	—.11	.33	.38	.22	.12	.28
	......	.09	.29	—.42	.53	.38	—.15
Müller-Lyer	.05	......	.00	—.30	—.04	.16	—.13
	.21	......	.24	—.31	.02	.38	.34
	—.11	......	—.01	—.14	—.24	.21	.06
	.09	......	.12	—.07	—.15	.20	.21
Distance	—.09	.00	......	—.35	.47	.03	.16
	—.28	.24	......	—.16	—.03	.06	.31
	.33	—.01	......	.25	.24	.02	.45
	.29	.12	......	—.30	.31	.64	.29
Weight	.67	—.30	—.35		.00	.21	.07
	—.29	—.31	—.16		—.20	.45	.13
	.38	—.14	.25		.00	.25	.17
	—.42	—.07	—.30		.52	.41	.31
Rectangle	—.14	—.04	.47	.00		.05	.27
	—.26	.02	—.03	—.20		.17	.30
	.22	—.24	.24	.00		.26	.21
	.53	—.15	.31	—.52		.62	.37
Triangle	—.32	.16	.03	.21	.05		.37
	.33	.38	.06	—.45	.17		.16
	.12	.21	—.02	.25	.26		.18
	.38	.20	.64	—.41	.62		.11
Cross	.02	—.13	.16	—.07	.27	.37	
	.05	.34	.31	—.13	.30	.16	
	.28	.06	.45	.17	.21	.18	
	—.15	.21	—.29	.31	—.37	.11	

The following table shows all of the coefficients of correlation which have been calculated, arranged according to magnitude so as to show, roughly, the frequency of coefficients of various magnitudes. In the first division of the work (nine tests) there are 36 correlations for a group of 54 women and the same number

for a group of 29 men. There are also for this same division of the work (eleven tests) 163 correlations for women and 153 for men obtained from the groups tested by individual experimenters. These groups range in size from 5 to 24 and contain the same persons as the groups of 54 and 29, but in different combinations and together with many others. Finally, there are two groups of about 20 women and two groups of about 20 men in the seven tests of the second division of the work, making 42 more correlations for each sex. In the last column of this table the whole 472 correlations are shown.

Positive correlations predominate among the men; only 4 of the 36 figures for the group of 29 are less than .05; two-thirds of those in the second division, and of those for individual experimenter's groups in the first division, exceed that figure. For the women positive and negative coefficients are about evenly distributed with a few more positive instances in the first division.

FREQUENCY OF CORRELATIONS OF VARIOUS MAGNITUDES

Amount of correlation	First Division		First Division Groups by individual experimenters		Second Division		All correlations
	Groups of 54 women	Groups of 29 men	Men	Women	Groups of 20 women A, and 21 women, B	Groups of 24 men A, and 19 men, B	
—1.00 to —.75	......	......	1	......	......	......	1
—.74 to —.65	......	......	0	3	......	......	3
—.64 to —.55	......	......	2	0	......	......	2
—.54 to —.45	......	......	1	3	1	1	6
—.44 to —.35	......	......	9	5	1	3	18
—.34 to —.25	2	......	12	6	6	2	28
—.24 to —.15	4	1	10	8	4	3	30
—.14 to —.05	4	1	26	12	5	4	52
—.04 to +.05	*7*	*2*	*17*	*13*	*10*	*3*	*52*
.06 to .15	10	8	16	19	2	4	59
.16 to .25	5	12	24	18	5	10	74
.26 to .35	4	3	14	14	5	6	46
.36 to .45	......	8	14	12	2	3	39
.46 to .55	......	1	8	11	1	1	22
.56 to .65	......	......	3	10	......	2	15
.66 to .75	......	......	5	8	......	......	13
.76 to 1.00	......	......	1	11	......	......	12
Total,	36	36	163	153	42	42	472

When the distribution of the entire 472 correlations is considered it is evident that more cases occur above zero than below and that relatively high positive correlations are much more frequent than correspondingly high negative ones.

On the whole, considering the very large number of correlations in question, the value of their averages and the way in which they are distributed, it is probable that an individual who is more suggestible than another in one of these tests will prove more suggestible in another. Yet the actual amount of the correlation is generally so small and the number of negative instances so great that the "probability" in the above statement can only be very slight. While it seems to be true that suggestibility is a trait more conspicuously developed in some individuals than in others, yet the individual differences are small and seem to be subject to reversal under the influence of conditions which are not within the control of the experimenter. Apparently the suggestions of the type used in the first division of the experiments are more apt to obtain consistent reactions from the same individual in different tests (as indicated by the correlations) than suggestions which depend upon the statement "most persons do so and so."

It has been observed that the correlations are more frequently positive and are generally higher for men than for women; in fact the figures for women are so low that without the support of the more definite data from the men they would be inconclusive. The present data do not afford any explanation of this difference between the sexes. Apparently there are men who present consistently distinct individual traits or idiosyncrasies when tested for suggestibility, while women are less consistent from test to test and do not show such marked individuality as the men.

Transmitted August 30, 1915.

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